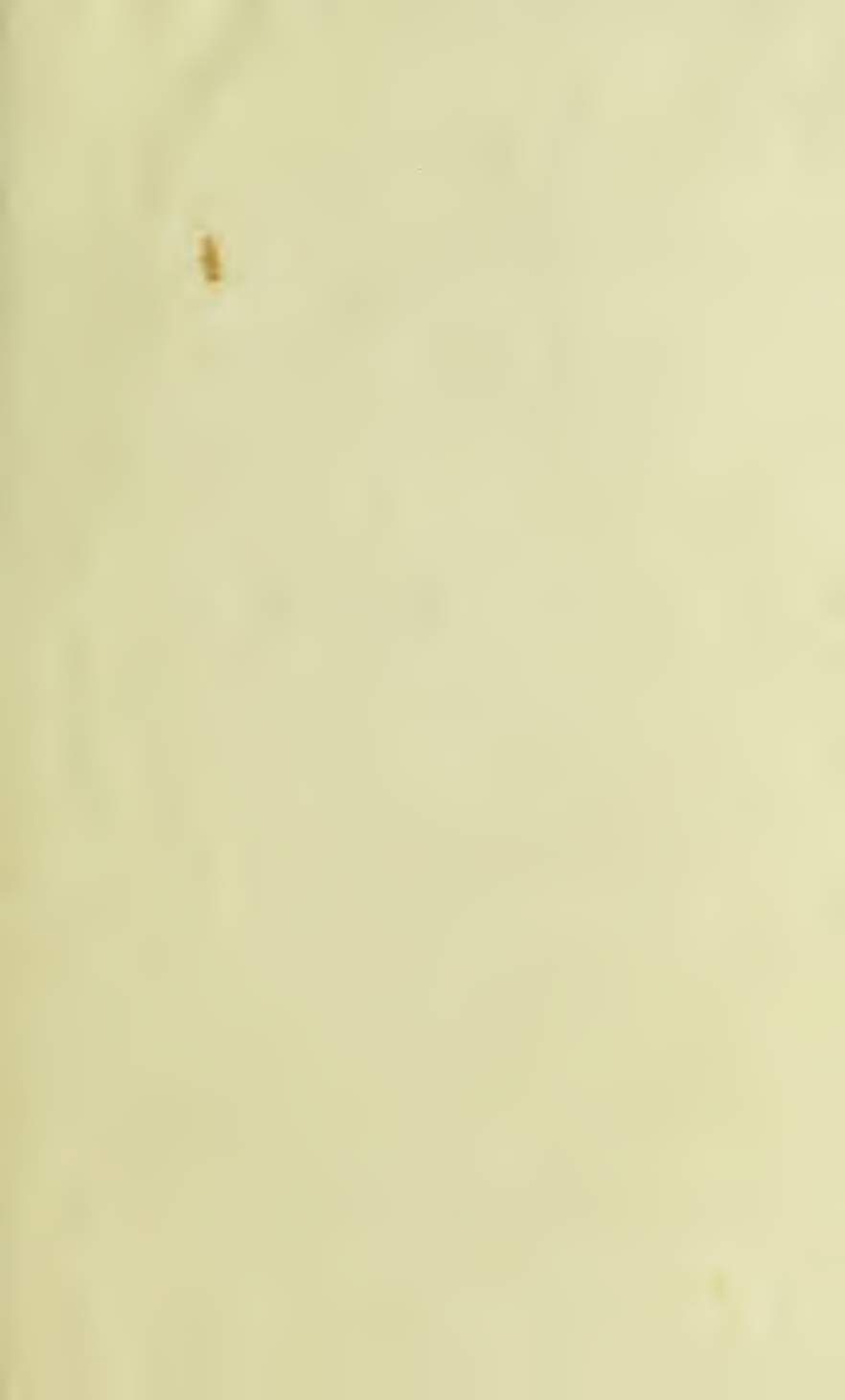
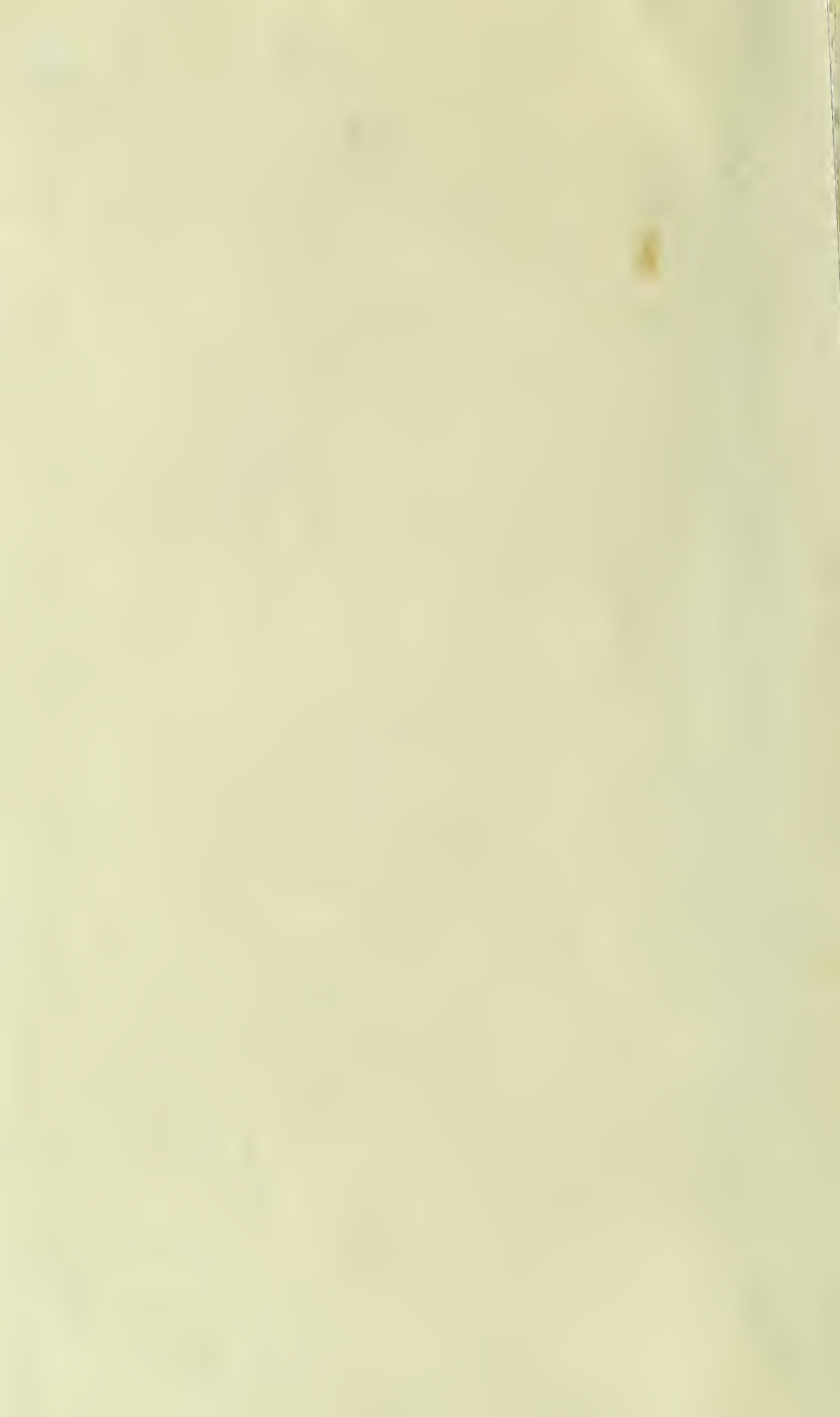






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THE
ANATOMY
OF THE
HUMAN BODY.

—*—
IN FOUR VOLUMES,
ILLUSTRATED WITH ONE HUNDRED AND TWENTY-FIVE ENGRAVINGS.

—*—
VOLUME III.
CONTAINING THE
NERVOUS SYSTEM.

PART I.
THE ANATOMY OF THE BRAIN, AND DESCRIPTION
AND COURSE OF THE NERVES.

PART II.
THE ANATOMY OF THE EYE AND EAR; OF THE
NOSE AND ORGAN OF SMELLING; OF THE
MOUTH AND ORGAN OF TASTE; OF
THE SKIN AND SENSE OF TOUCH.

—*—
By CHARLES BELL,
FELLOW OF THE ROYAL COLLEGE OF SURGEONS OF EDINBURGH.

—*—
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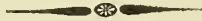
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INTRODUCTORY VIEW
OF THE
NERVOUS SYSTEM.



THERE can be no natural division of the nervous system, for it is a whole so connected in function, that no one part is capable of receiving or imparting any sensation, or of performing the operation of the intellect.

The system has, notwithstanding, been arbitrarily divided into the brain and nerves; the brain being subdivided into the cerebrum, cerebellum, and medulla oblongata; while the nerves are subdivided into the nerves of the senses, the vital and involuntary nerves, the nerves of voluntary motion.

The **BRAIN** is defined to be that soft mass contained within the cranium, from which the nerves are propagated to the organs of the senses and over the body, bestowing sensation, and acting as the agents of the will. It is believed to be the receptacle of sensation and the instrument of thought; but our ideas of its functions are vague and imperfect.

The substance of the brain is delicate and soft, and possesses a degree of elastic resistance; but the nerves are firm, hard, and devoid of elasticity; because, though their peculiar substance has equal delicacy with the brain, their membranes give them firmness and strength to enable them to pass through the moving parts of the body without being bruised, or having their function affected. The substance of the brain is protected and supported by the scull and dura mater: its peculiar matter is supported and nourished by the pia mater. The nerves contain the same matter with the brain; but in their course through the body this matter is disguised by the peculiar structure of their membranes, which, while they support their substance, nourish them also, as the membranes do the

brain. But the extremities of the nerves are again reduced to the same delicate texture with the brain.

In the structure of the brain and nerves there is an analogy with the other parts of the body. In a bone or a muscle there is the same intexture of membranes supporting the peculiar substance which is the characteristic of the part, and conveying blood vessels for its nourishment. The muscular fibres, or the earth of bone, are, in the midst of this investing membrane, peculiar parts distinct in their properties, as the medullary substance of the nerves is amidst the cellular membrane, which divides them into fasciculi, and gives them their fibrous appearance.

When it is said that the nerves are productions of the brain, we are not to understand that they are propagated from it to the distant parts of the body, as if drawn out from it like a thread from the wool. In the embryo the nerves are laid in their sheaths, extending to the remotest parts of the body.—They are connected with the brain, and in this sense they may be considered as elongations of it, the perfect function of both depending upon their union. But they have powers independently of the brain; and often an animal is produced having no brain; and yet, in such embryo, the animal functions are sufficiently perfect.

In the same manner, when the trunk of the nerve of a limb is cut, it is only deprived of its connection with the brain, the centre of the nervous system; and little further effect is produced than the destruction of the powers of the will over the limb; the nutrition and growth of the part continue, and the action of those parts, which are independent of the will, as the muscular power of the vessels of the limb, remains entire.

The nerves of animals are in proportion to the size of their bodies; but in many of the great tribes of animals the brain bears no such proportion. The nerves of the organs also bear a relation to the necessities of the animal, not to the size of the brain. If the procuring of sustenance depend upon the power of the organ of smelling, or upon the ear, or the eye, or even the bill, an additional supply of nerves is provided, or a peculiar apparatus of nerves suiting to the exigency. This also shews a property in the nerves independent of the brain.

We come to this conclusion, that the nerves are analogous to the brain, (being indeed a matter similar in structure and function to it,) diffused over the body, and included like it in the pia mater, or in a similar delicate and vascular membrane, and that their proper substance, consisting like the brain of a cineritious and medullary matter, is nourished by these membranes. We must conclude also, that they are more indepen-

dent of the brain than the brain is of them ; for the nerves are capable of continuing the operations of the animal body independently of the brain ; but without the communication of sensation through the nerves to the brain, its function must be unexercised.

The nerves, in their course through the body, form ganglions, plexus, and networks. By these a more universal connection of the several branches of the system is maintained, so that few if any nerves can be traced to one point or origin.—When the nerves form ganglions, (which are like knots or swellings upon them,) their fibres are split and irregularly dispersed, while there intervenes a peculiar substance resembling the striæ of the cineritious substance in the brain. From every analogy we must suppose, that those ganglions answer in a less degree the purpose of that more universal connection which the nerves have with the brain.

In their extremities again the nerves are peculiarly organized : a nerve, in its course, is incapable of receiving any distinct sensation ; when injured, it conveys to us the undefinable sensation of pain ; and from the connection with the muscles, and with the whole system, it shakes the limb with involuntary tremors, or sudden spasms. The susceptibility of those peculiar impressions which the organs of the senses convey, depends upon a structure distinct from that of the brain, and distinct also from that of the nervous cords ; and this organization is so peculiar, that the nerves of one sense are quite incapable of receiving the impressions which those of another are fitted to convey, though apparently to our reasoning those impressions appear to be capable of producing a stronger effect upon the nerves.

As the vital organs must be in perpetual action to support life, nature has guarded those functions by making them independent of the will, and less immediately dependent on the function of the brain. This is a provision which allows the exhausted mental and bodily functions to be recruited by sleep, while the operations of the animal body necessary to life go on uninterrupted.

It is an additional reason for believing the use which we have assigned to the plexus and ganglions to be the true one, that those nerves which supply the vital organs arise by small twigs from the brain, take a long course through the body, and neither swell out into large nerves, nor are finally distributed until they have received many additions, and formed several remarkable plexus and ganglions.

As in sleep the vital functions continue uninterrupted, so the diseases of the brain, which resemble sleep, suddenly de-

prive the body of all voluntary exertion, while the vital motion remains for a time unimpaired, and sinks gradually; for no part of the body is altogether independent of the healthy function of the brain.

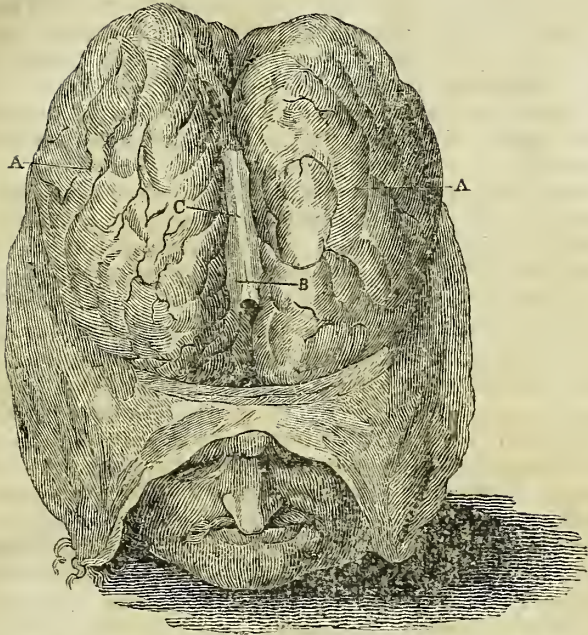
It is necessary also that we should recollect the connection of the higher attributes of a living being with the animal economy.

The brain, the nerves, and the nervous expansions in the organs of the senses, are dependent for the perpetual renewal and support of their function upon the circulation of the blood. We should be tempted to imagine, that the nervous system were a nobler part of the economy, did we not frequently see the powers of the mind as well as the functions of the nerves disturbed, or altogether overthrown by the irregularities of the bodily system; were we not thus reminded of that circle of connections and mutual dependences which support the whole. If the tide of blood flow too rapidly upon the brain, the intellect is disordered, the ideas come in rapid and irregular succession. If the exit of the blood from the head be obstructed, there is an obstruction to the circulation of the blood in the extremities of the vessels of the brain; the function of the brain is suddenly suppressed, because, though its attributes seem so peculiar, it requires the perpetual circulation of the blood through it to renovate its powers.

The effect of the circulation of the blood through the nerves of the limb is not less remarkable. If the nerve of a limb be cut or tied, the animal can no longer move the limb, having lost the power of the will over it. But if the great artery of a limb be tied, the function of the nerve is, in a short time, equally destroyed, because the circulation of the blood through the nerve being obstructed, it loses its powers, and is no longer a living part.

Thus, whilst the moving powers of the circulation of the blood are dependent on the state of the nervous system, the nervous system is as immediately dependent on the healthy state of the blood, and the velocity of the circulation.

With this general view of our subject, we proceed to investigate the anatomy of the brain as a distinct part, without forgetting the unity of the system.



A. A. Hemispheres of the Cerebrum.—B. Corpus Callosum.—C. Raphe.

CHAP. I.

OF THE MEMBRANES OF THE BRAIN, AND OF THE SUBSTANCE AND TEXTURE OF THE BRAIN ITSELF.



OF THE DURA MATER.

MANY authors, while they describe the cranium as containing the brain, conceive that it also gives it shape. But the brain is formed before the bones which invest it. The first thing that we observe in the embryo is the disproportionate size of the brain to the diminutive body. The ossification of the bones of the skull is a gradual process. The brain, already

formed, is invested with the strong membranes; and betwixt the laminæ of the outer membrane, the points of ossification commence, and are not completed until the ninth year. The bony matter, which is deposited betwixt the layers of this membrane, retains a firm connection and interchange of vessels with the now apparently distinct membranes on its inner and outer surfaces. The outer layer, which is so strong in children newly born, becomes the delicate pericranium, whilst the inner layer is the dura mater. Thus we find that the bones of the head are moulded to the brain, and the peculiar shapes of the bones of the head are determined by the original peculiarity in the shape of the brain.

This view corrects an error into which many have fallen, that the dura mater and the vessels ramifying upon it impress their form upon the solid bones, and wear channels upon their surface by their incessant pulsation. The membranes and vessels precede the formation of the bone, and the osseous matter is deposited so as to be moulded round the vessels.*

Thus the dura mater may be considered as the internal pericranium.†

The dura mater‡ is a firm and somewhat opaque membrane. When the scull-cap is torn off, and it is cleaned from the blood which escapes from the ruptured vessels, it is seen marbled with azure and rosy colours. It partakes more of the former in youth than in those advanced in years, or in the robust and sanguineous.§ Its outer surface is rough, from the adhesions to the bone being torn up; but on the surface lying in contact with the brain, it is smooth, shining, and of a pearl colour.

Although the dura mater is really the strongest membrane of the body, it is yet divisible into laminæ; these are strengthened and firmly connected by the intertexture of strong fibres. Most anatomists describe it as composed of two laminæ.—Some however describe three laminæ—the outer lamina, or squamosa; the middle, or filamentosa; and the internal (being smooth and uniform,) the lamina membranosa.||—But to

* Albini Acad. Anat. "Quomodo cranium crescendo accommodat se eis quæ continent."

Fischer, Dissertatio de modo, quo, ossa se vicinis accommodant partibus.

† Some regard only its external lamina as the internal pericranium. Fallopius first viewed the dura mater in this light, and he is followed by the best anatomists.

‡ The membranes of the brain have the name of *mater*, because they defend the brain, and protect its tender substance, or, according to some anatomists of the Arabian school, because the other membranes of the body are produced from them. Before Galen, the term *Meninx* was common to all the membranes of the body, afterwards it was appropriated to those of the brain.

§ Malacarne Encefalotomia Nuova, p. 19.

|| Malacarne, p. 22. It is described as partly tendinous, partly ligamentous:



the Skull:cap of a Child before it be fully Ossified. 1 the Fontanelle. 2 the Pericranium extremely Vascular. 3 the Longitudinal Sinus opened by cutting up the membrane in the direction of the Sagittal Suture.



separate the dura mater into such laminæ, it will, I believe, be necessary to dry it and tear it into shreds. No doubt it may be possible thus to tear it, as some have done, into four, six, seven, or even eight laminæ or squamæ. It is to be regretted that anatomists should have been proud of such dissections, or that any such descriptions should be thought creditable to their authors, or discoverers as they are called.

The dura mater is insensible; it has, in the way of experiment, been pricked and injured by every possible contrivance, by mechanical and by chemical stimulants; yet the animals, the subjects of such cruel experiments, have given no sign of pain.* Before this fact of the insensibility of the dura mater was thus established, physicians regarded this membrane as the seat and origin of many diseases.†

Formerly the natural connection of the skull and dura mater was so resolutely denied—so hotly contested among the various parties in anatomy and surgery, that we might, by reading their disputes, almost doubt one of the plainest and most obvious facts, were not the closeness of this connection sufficiently proved by the manner of the original formation of the cranium, by the resistance to the tearing up of the cranium, and by the bleeding surface of the dura mater; or, if further proof be required, we may macerate these bones and their membranes in acids, when the laminæ of the dura mater will be seen intimately connected with the bone, while the pericranium and outer laminæ of the dura mater are seen to be continued into each other‡, by the intermediate cellular texture in which the earth of the bones is deposited.§

The dura mater adheres more firmly to the bone in young subjects, because the bone is yet imperfect, and its surface spongy and rough; and, for the same reason, it is more firmly attached to the skull in the chronic hydrocephalus, because the ossification is imperfect.

that is to say, of a nature resembling these, yet not altogether the same. Vicq d'Azyr found it separated by purulent matter into two laminæ, the fibres of which had a different direction. Acad. de Sciences, An 1781. p. 497.—Bartholin Sp. Hystor. Anatomia.

* Zinn. Exper. circa corpus callosum, cerebellum, duram meningem.—Mem. par Haller sur les parties sensibles et irritables.—Blegny Journal de Med. An 1. p. 16.

† See Hoffman. Med. Ration. part 2. sec. ii. c. 1. § 2. and Boneti Sepulch. Anat. lib. i. sec. 1.

‡ Vicq d'Azyr Memoir. de l'Acad. Roy. 1781, p. 497, and Malacarne (Adezenze della D. M. allæ pareti interne del cranio), p. 24.

§ Taking a portion of the dura mater betwixt the finger and thumb, we can feel the two lamina moving upon each other, from a slight degree of laxity in the connecting cellular substance. This cellular texture is demonstrated by Malacarne, by forcibly injecting quick-silver betwixt the layers of the membrane.

It frequently adheres so firmly to the scull-cap, as to leave its outer lamina adhering to the scull when it is raised. It adheres more firmly along the sutures, and from this cause, when the scull is injured, and matter is formed under it, the dura mater will be separated on each side of the suture, and still retain its adhesion to the suture, so as to divide the matter, and, consequently, prevent the full evacuation of the matter when the trepan has been applied on one side of the suture. The dura mater adheres also with peculiar firmness to the base of the scull, because of the numerous chinks and foramina.

GLANDS OF THE DURA MATER.

UPON the external surface of the dura mater there are little holes, from which emerge fleshy-coloured papillæ, and which, upon examining the scull-cap, will be found to have corresponding foveæ. These are the glandulæ Pacchioni.* They are in number from ten to fifteen† on each side, and are seen chiefly lateral to the course of the longitudinal sinus. These bodies were supposed by Pacchioni to be glands. When pressed they give out a fluid; but in this they do not differ from the loose common cellular membrane. As they are chiefly seen along the line of the great sinus, and are not scattered over the whole dura mater, their supposed use of moistening the surface of the membrane‡ is quite improbable; and, indeed, this is a part of that unfounded hypothesis which supposed an interstice betwixt the dura mater and scull, and ascribed motion to this membrane. The surfaces of the dura and pia mater, where they are in contact, being of the nature of the secreting surfaces of the investing membranes of the other viscera, require no such further aid in moistening them, or preventing their adhesion. Many glands are described by authors in the substance, and upon both surfaces of the membrane.§ Of the bodies which adhere to the surface of the pia mater, and of those also which are to be seen in the sinuses, we shall speak afterwards, when considering the veins which enter the longitudinal sinus.

* See M. Littre Acad. Roy. des Sciences 1704, Hist. p. 32. art. 19.

† Haller, El. Phys. p. 106, Mem. par M. Vicq d'Azyr Mem. de l'Acad. Roy. 1781, p. 497.

‡ Viz. the opinion of Fantonius.

§ Malacarne, sec. 94.

ARTERIES OF THE DURA MATER.

THIS membrane must necessarily be supplied with vessels for its own nourishment, for that of the contiguous bone, and for the perpetual exudation of the fluid, or halitus rather, which moistens or bedews its internal surface. We may divide the arteries of the dura mater into anterior, middle, and posterior. The first proceeding from the ophthalmic and ethmoidal branches; the second from the internal maxillary and superior pharyngeal; the posterior from the occipital and vertebral arteries.

The principal artery of the dura mater, named, by way of distinction, the great artery of the dura mater, is derived from the internal maxillary artery, a branch of the external carotid. It is called the spinalis, or spheno-spinalis, from its passing into the head through the spinous hole of the sphenoid bone, or meningea media, from its relative situation, as it rises in the great middle fossa of the scull.* This artery, though it sometimes enters the scull in two branches,† usually enters in one considerable branch, and divides soon after it reaches the dura mater into three or four branches, of which the anterior is the largest; and these spread their ramifications beautifully upon the dura mater, over all that part which is opposite to the anterior, middle, and posterior lobes of the brain. Its larger trunks run upon the internal surface of the parietal bone, and are sometimes for a considerable space buried in its substance. The extreme branches of this artery extend so as to inosculate with the anterior and posterior arteries of the dura mater, and through the bones (chiefly the parietal and temporal bones) they inosculate with the temporal and occipital arteries.‡

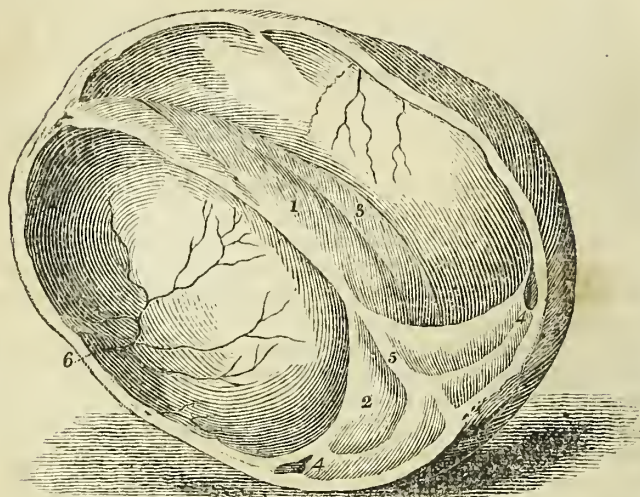
The meningeal artery has been known to become aneurismal and distended at intervals, it has formed an aneurism, destroying the bones, and causing epilepsy.§

* Malacarne, parte i sec. 100.

† Soemmerring de Corp. Hum. fab. tom. v. p. 142. This is not the sole artery sent to the dura mater from the internal maxillary, a twig also rises from that branch which goes to the pteregoid muscles and parts about the Eustachian tube—it enters the scull, and is distributed to the 5th pair of nerves, and to the dura mater and cavernous sinus. Another enters with the inferior maxillary nerve by the foramen ovale, and rises upon the dura mater.

‡ Malacarne.—“Antrorsum ramis arteriæ ophthalmicæ, retrorsum ramis arteriarum vertebraliæ, secuti etiam crebro sibi ipsi, nec non epicranii ramis, e. g. ex arteria occipitali ortis etc. in embryonibus potissimum conspicuis inosculatur.” Soemmerring, tom. v. p. 142.

§ Malacarne, p. 1. sec. 105. “Possono le arterie, della D. M. divenire aneurismatiche, il che ho veduto in due cranii, in uno dei quali l'arteria spinosa era

The Skull Cap with the D. M. adhering.

1. Falx. 2. Tentorium. 3. Longitudinal Sinus. 4. great Lateral Sinus. 5. Fourth Sinus. 6. artery of the D. M.

OF THE SEPTA WHICH INTERSECT THE BRAIN.

Those septa, or, as they are called, processes of the dura mater, being extended across from the internal surface of the cranium, support the brain in the sudden motions of the body,

tutta gozzi tanto a destra quanto a sinistra, i maggiori dei quali (ed erano cinque dal primo, e nove dall' altero lato) poco superavano la grossezza dei pifelli : nell' altero ancor giovanile si vedevano due soli gozzi uguali in diametro al mignolo sul tronco mezzano dell' arteria spinosa rempetto alla metà del parietale sinistro, distanti nove linee circa l' inferior anteriore dall' altro." Part i. § 105. We have also the following case from Malacarne. "Juvenis ætatis 22 annorum, sanguinei temperamenti, post vehementissimos, et frequentes epilepsix motus in nosocomio D. Joannis, tumente in summa bregmatis ossium parte capitis cute, sub meis oculis moriebatur. D. Caccia in hac nostra universitate tunc Botanicæ professor, quem mihi patronum a morte peremtum adhuc desleo, ut cadaver aperiretur jufferat, atque in ejusdem capite ex ea parte, qua tenuissima devenerant ossa, ob arteriarum subrepentium inter duræ matris laminas aneurismata, os quoque omnino deficiens reperiebatur, sub capitis integumentis aneurismata magnitudinis ovi columbini, exiguo, perruptoque foramine aperto, ut sanguis sub integumentis concrevisset ; atque tunc novimus ad ea aneurismatum loca, quæ quidem utrinque erant, in vehementia morbi agrum pugnos infligere consuevisse."—A curious case occurred lately to a friend of mine : A boy was wounded with an arrow in his head ; it stuck in the parietal bone ; upon withdrawing it, there was a profuse hæmorrhagy, for its point had struck the artery of the dura mater. The surgeon

and prevent the mutual gravitation of its parts. These partitions are formed by the internal lamina of the dura mater, which is reflected as the peritoneum is to form the mesentery, or the pleura to form the mediastinum.

The falx is the largest of the partitions ; it is attached to the cranium in the line of the sagittal suture, and reaching from the crista galli of the ethmoid bone to the middle of the tentorium, or to the crucial ridge of the occipital bone, it passes deep into the middle of the brain, and divides it into its two hemispheres. It is in shape like a scythe, for anteriorly it does not pass so deep into the substance of the brain ; but it gradually becomes broader, or descends deeper betwixt the hemispheres, as we follow it backwards, which, with the curve, it necessarily takes from the shape of the cranium, has obtained it the name of falx : it is also called septum sagittale, verticale, or mediastinum cerebri.

The TENTORIUM separates the cerebrum and cerebellum. It stretches horizontally over the cerebellum, and sustains the posterior lobes of the cerebrum. It is formed by the inner lamina of the dura mater, reflected off from the os occipitis along the whole length of the grooves of the lateral sinuses, and the edge or angle of the temporal bones. This septum, thus running round the cavity of the cranium, divides it into two departments ; the upper one for the lodgment of the cerebrum, and the lower for the cerebellum. But to allow the union of these two great divisions of the encephalon, a circular opening is left upon the anterior part of the tentorium, which is called the notch of the tentorium.

There is a little process of the dura mater which may be called the FALX of the CEREBELLUM. It runs down upon the internal spine of the occipital bone from the tentorium, gradually contracting until it terminates on the margin of the great occipital foramen. It serves as a kind of ligament strengthening the tentorium, while it divides the cerebellum. It enters, however, but a little way betwixt the lobes.

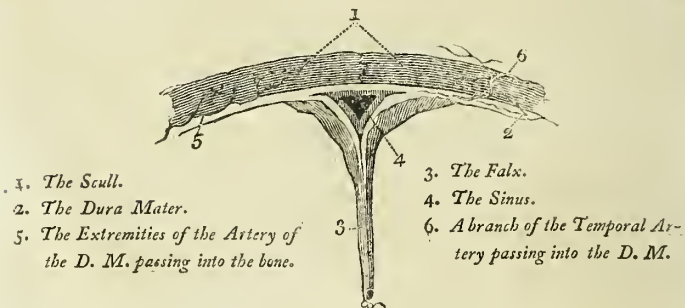
The falx and tentorium being connected and continued into each other at their broadest part, they mutually support each other, and are extremely tense. This tenseness depends on their mutual support, for when one of them is cut the other falls loose.

was cautious of applying pressure, lest the blood should force its way betwixt the dura mater and bone, or diffuse itself upon the surface of the brain ; he bled the boy largely in the arm, but it had no effect upon the hæmorrhagy ; and fearing to bring on a greater degree of inflammation by applying the trepan, he made a slight compression, and in the now languid state of the circulation, the bleeding was suppressed.

OF THE SPHENOIDAL FOLDS.

The lateral extremities of the tentorium are continued forward into acute lines, formed by the duplicature of the dura mater coming off from the edges of the pars petrosa of the temporal bones, and take firm hold on the posterior clynoïd processes. From these two points a fold of the membrane stretches forward on each side to the anterior clynoïd process, forming thus a hollow or cell for the lodgment of the pituitary gland. Another fold or duplicature of the dura mater runs onwards a little way from the edge of the little wing of Ingrassiatus. These are the sphenoidal folds.

Where the internal lamina of the dura mater forsakes the external to form the falx and tentorium, it leaves a channel or triangular canal; the basis of which triangle is the lamina of the membrane investing the cranium, while the tension of the partitions carries the apex out into an acute point. This forms a channel for receiving all the blood of the veins, and this tension and triangular shape give a degree of incompressibility to the canals. These are the sinuses which receive the veins of the encephalon, and guard them from compression :—

Section of the Longitudinal Sinus.

Upon the surfaces of the dura mater there are many lacerti, or slips of fibres, which are intricately interwoven with the main body of the membrane, and strengthen it. These fibres are peculiarly strong in the angles, where the duplicatures pass inwards, giving firmness to the sinuses, and allowing the veins to insinuate their trunks betwixt them; these fasciculi,

or slips of fibres, and the sides of the sinuses, are the *cordæ Willisianæ*. They were considered by Baglevi and Pacchioni* as the tendons of the muscles of the *dura mater*. Pacchioni conceived that this membrane was muscular. Vicq d'Azyr observes, that in inflammation of the *dura mater* he has seen it red, and of a fleshy appearance; and that such a circumstance might have deceived Pacchioni, and made him believe that there were muscular bellies.†

These physicians conceived that the contraction of the *falx* and *dura mater* raised the *tentorium*; they even conceived that the action of the heart depended upon this motion of the *dura mater*.‡ They were deceived by the pulsation in the arteries of the brain, communicated to the *dura mater*, after the operation of *trepan*, or in their experiments on living animals.§

The motion communicated to the *dura mater* those Italian anatomists conceived to depend on the rising of the *tentorium*. This motion, which is occasioned by the beating of the arteries of the brain, had been long before observed: || some conceived it to be a motion in the brain itself, others believed it to depend on the sinuses.¶

The motion caused by respiration was likewise observed.** M. de Lamure's conclusion was, that the motion of the brain was caused by the reflux of the blood towards it from the *vena cava* in expiration.†† He undertook to demonstrate this; and he conceived his proof to be good, when, by pressing the ribs of a subject, he saw the reflux blood swelling the jugular and abdominal *cava*. Haller observed the jugular veins swell, and become turgid, during expiration; and he concluded, that the motion of the brain was occasioned by the reflux blood distending the sinuses of the brain. But he did not believe, as

* These were Italian anatomists. Pacchioni was physician to Clement XI.

† Mem. de l'Acad. Roy. 1781.

‡ Duverney.

§ There is a distinction in the movement of the *dura mater* to be observed upon opening the skull; one depending upon the pulsation of the arteries of the brain, the other caused by an obstruction to the exit of blood from the cranium, dependent upon the lungs. "On voyoit bien la pulsation des arteres du cerveau, qui muniquoit quelque mouvement à la dure mere, mais ce mouvement n'avoit aucune symmetrie avec celui de la respiration. Fatigué de ne rien voir de tel, j'avois si bien vû je comprimai la poitrine de l'animal: aussitot le cerveau se gonfla évidemment par le reflux du sang de la poitrine qui remplissoit la jugulaire. — Je lâchai la poitrine, et le cerveau redescendit."—Exper. 78. Mem. ii. par Haller, sur le Mouv. du cerv.—"Il arrivoit pourtant de tems en tems et sans que cela continuât que le cerveau se soulevoit dans l'expiration, et se laissoit retomber dans l'inspiration." Exper. 79. f. chat.

|| By Coiterus, Riolanus, Bartholin.

¶ Diemerbroeck.

** M. Schlichting Mem. des savans Etrangers, 1744. Leery, Mem. présentés à l'Acad. des Scien. par divers savans Etrangers.

†† M. de Lamure; vide l'Acad. de Sciences, 1744.

Lamure did, that this motion took place before the opening of the cranium, as well as after it.

When the skull is opened by a wound, the dura mater still protects the brain, resisting inflammation, and giving the necessary and uniform support to the more delicate substance and vascular membrane of the brain; but when the dura mater is lacerated by the trepan, or punctured, or worn by the pulsation against the edge of the bone, there may be sudden hernia of part of the brain from coughing, or a rapid and diseased growth from the pia mater forming a fungus. Such fungus is, in some degree, peculiar to children, and is occasioned, I conceive, by the taking away of that due compression which the resistance of the dura mater ought to give.

OF THE PIA MATER.

WHILE the dura mater is closely connected with the cranium, and in contact with the surface of the brain, but still unconnected with it, except by means of veins entering the sinuses (and that only in the course of the sinuses :) the pia mater is closely attached to the brain, and passes into its inmost recesses. While the dura mater is firm and opaque, and not prone to inflammation, the pia mater is delicate, transparent, and extremely vascular. Like the dura mater, it is not endowed with sensibility; * it is of great strength, considering its apparent delicacy. †

The pia mater, which was formerly considered as a simple membrane, consists, in reality, of two membranes, the tunica arachnoides, and the proper pia mater, or tunica vasculosa. ‡

The TUNICA ARACHNOIDES was discovered and commented upon by a society formed by Blasius Sladus Quina and Swammerdam. § They called it Arachnoides, because of its extreme tenuity. It was called also Membrana Cellulosa, from the appearance it took when they insinuated a blow-pipe and blew it up, separating it from the pia mater.

This membrane is without the pia mater; and while the pia mater sinks down into the sulci of the brain, this covers the surface uniformly, without passing into the interstices of the convolutions, or into the ventricles. ||

* Haller, Oper. Minor. de. Part. Corpor. humani sent. & irrit.

† Sir C. Wintringham Exper. Essays. Taken comparatively, it is stronger than the aorta.

‡ There are many, however, who with Lieutaud consider the arachnoid coat as the external lamella of the pia mater.

§ This was in 1665. I am, perhaps, not correct in saying they discovered it; for Varolius describes it plainly, covering the medulla oblongata.

|| Haller Elemen. Phys. tom. iv. sec. viii. p. 7.

This membrane is so extremely thin, that it cannot by dissection be separated for any considerable space from the pia mater, and least of all, over the middle hemispheres of the brain. By the blow-pipe, indeed, we may raise it into cells, but it immediately subsides again; on the posterior part of the cerebellum, on the spinal marrow and base of the brain, it is more easily raised and demonstrated.* It does not pass deep into the sulci of the brain, but unites them by an extremely delicate cellular texture.

The view which would incline me to consider the tunica arachnoides merely as a layer of the pia mater is this: when the vascular pia mater descends into the sulci, the tunica arachnoides does not follow it, but keeps to the uniform surface of the brain; but when this vascular membrane is about to enter into some of the lesser sulci which are within the larger, it again parts with another lamella, while its more vascular part descends still deeper into the brain.

OF THE PROPER PIA MATER, OR TUNICA VASCULOSA.

The pia mater is a simple membrane, without either tendinous aponeurotic or muscular fibres. It is extremely vascular, but it is transparent in the interstices of its vessels: it is the membrane which immediately invests and connects itself with the substance of the brain; and although delicate, it forms the support and strength of its cineritious and medullary substance. All vessels distributed in the body, however minute, are always conveyed in membranes; the pia mater then follows, or rather conveys the vessels not only into the cavities of the brain, but to every part of its substance, it being intimately blended with it.† We see it more distinctly descending in strong plicæ into the interstices of the convolutions; nor is it into them only that it enters, but into every pore which conveys a vessel.‡ The pia mater as it passes into the substance of the brain, divides and subdivides into partitions and cells, and every capillary vessel, and every molecule of the substance of the brain is invested and supported by its subdivisions. The pia mater is to the brain what the cellular membrane is to the other viscera

* F. Ruyschii Responso ad A. os Goelecke Epistol ix. See Bidloo, table 10; but the membrane is so delicate (nulla detur in corpore subtilior, Ruysch) that it can be but very imperfectly represented by engraving.

† Columbus, the assistant of Vesalius, and afterwards Professor in Rome, explained this intimate intertexture of the pia mater with the proper substance of the brain, so far back as 1559.

‡ When we tear off the pia mater from the brain (for it cannot be called dissection,) it does not adhere merely at the sulci, but to the whole surface of the convolutions; and every where small vessels enter, and with these vessels descends also the lamina of the pia mater.

and parts of the body ; for it is the peculiar matter lying in the interstitious cellular membrane (as in muscles, bones, &c.) that gives the peculiarity of character to the parts ;* the cellular membrane itself is nearly alike in all ; therefore, in my judgment, the pia mater is rightly considered by some anatomists as a cellular substance.†

Malacarne says, I am much inclined to consider it with the illustrious Haller, as being composed of lamina, like common adipose membrane, and that the extreme arteries ramify through its cells, for, with a blow-pipe, we can raise it into cells like the common membrane ; and if this be carefully done, the air may be made to pass from cell to cell, following the arteries in their course betwixt the lobuli, and in the substance of the brain.‡ We can follow the pia mater into the ventricles, by tracing it betwixt the posterior lobe of the cerebrum and the cerebellum, where it forms the velum interpositum of Haller, and passes under the fornix. We can follow it also into the posterior horn of the lateral ventricles from the base of the brain, where the branches of the middle artery of the cerebrum pass into the lower part of the choroid plexus ; we trace it also into the bottom of the fourth ventricle. The pia mater lining the ventricles is more delicate, and less vascular than that seen upon the surface, and betwixt the convolutions of the brain.

It has been said that the ventricles of the encephalon served to increase the surface of the pia mater, and that whatever purposes are served by that membrane and its vessels on the surface of the brain, we must suppose the same performed by it within the ventricles.§ This seems more like a weighty conclusion than it really is. We have seen how minutely distributed the pia mater is through the substance of the brain, independently of the ventricles ; and we shall find that the ventri-

* “ Sed cum continuo triduo in inquisitione faciendo perseverassem ; tandem deprehendi cerebri fibrillas eadem ratione, continuataque ferie, sibi invicem annexas esse ; quemadmodum fibrillas carneas tendinibus adhærere demonstravi ; cum igitur illam cerebri cum vasibus sanguineis connexionem deprehendissem ; et eam, quam ante dixi, variorum fructuum compagem attenderem ; iterum conclusi dominum, univervi conditorem, in rerum creaturarum fabrica eandem vel consimiles fere leges tenuisse.” — “ Igitur adverti fibrillas certo loco sibi conjunctas, mox alio loco ab invicem divertere, paulo post iterum coeuntes. Et, si recte memini, consimiles conjunctiones observavi in musculis cordis,” &c. Leeuwenhoek Epist. Phys. xxxiv.

† Bergen. Program de pia matre. See Haller Anat.

‡ Such is the profusion of vessels distributed to inconceivable minuteness, that it has been considered as entirely composed of vessels, and received the name of chorion, from the membrane of the secundines. Galen de usu part. l. viii. cap. 8. — Malacarne, part I. sec. 243.

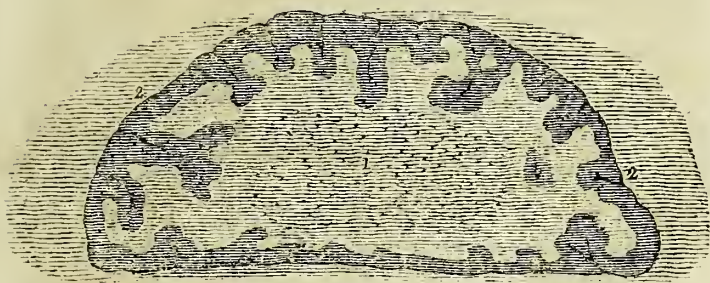
§ Dr. Monro's Nervous System, chap. vi.

cles have important uses, without the necessity of supposing them so subservient to the distribution of the pia mater.

As the tunica arachnoides is of a peculiar nature, and has few if any vessels, and as it covers the external surface of the brain only; it seems to me probable that this membrane is the cause why effusions in the ventricles are so common, and why fluids are so seldom found betwixt the surface of the brain and the dura mater. When by the diseased action of the vessels of the pia mater on the surface of the brain an effusion is thrown out, it very seldom lies upon the surface unconfined; but frequently fluids are contained in sacs of the arachnoid coat, betwixt the convolutions of the brain, or raise it into pellucid vesicles upon the surface. The want of a tunica arachnoides upon the pia mater of the ventricles, may be a cause of the fluids being so much more readily secreted into them.

The raising of the pia mater into vesicles by the action of the vessels of the pia mater, is rather an argument for the distinct nature of these membranes. The tunica arachnoides is raised by the action of the vessels of the pia mater, as the cuticle is raised into blisters by the inflammatory action of the vessels of the cutis, while no other membranes of the body take such an appearance in their disease. They inflame, indeed; they thicken; their lamina become more distinct, or their cellular substance fills with water, or hydatids are formed in them; but this appearance of water secreted under the tunica arachnoides is quite peculiar.

Section of the right Hemisphere.



1. Central Medullary Matter.....2. Cineritious or Cortical Matter.

OF THE SUBSTANCE OF THE BRAIN.

The cerebrum and cerebellum consist distinctly of two very different substances; the cineritious and medullary matter.—

The cineritious, or ash-coloured matter, forms the superficial or outer part of the encephalon, and is therefore called also the cortical part. The cineritious matter varies much in colour; in the crura cerebri it is very dark; in the pons varolii it is redder; in the corpora olivaria* it is yellower. The consistency of this matter also varies considerably in different parts; it is soft in the base of the brain, betwixt the optic nerves and anterior commissure, and in the third ventricle. The medullary matter is chiefly in the internal part of the brain, forming a kind of nucleus or white central part; but in many parts of the brain, there is a mixture of these which form striæ†; and in some of the eminences, the internal part is cineritious, while the external part, or what we might here call the cortical part, is medullary.‡

The cortical or cineritious substance does not blend gradually with the white medullary matter, but on the contrary, their line of distinction is abrupt: an intervening substance has been observed. In inflammation of the brain, particularly, it has been said, that this third substance has been found. This may be merely the effect of light upon the union of the two substances. We, however, often observe an appearance of successive coloured circles upon the edge of the medullary matter of the arbor vitæ, in the cerebellum.

It has been asserted by M. Ludwig,§ that the masses and striæ of the cineritious substance, dispersed through the internal parts of the brain, have a communication with each other. This, however, is denied by Vicq d'Azyr.|| He conceives, that the cineritious substances of the pons varolii, or of the corpora olivaria, have no communication with the cineritious substance in any other part of the brain; and that in several parts of the brain the cineritious substance is surrounded and isolated by the medullary matter. Its great importance (which

* Vicq d'Azyr.—“Exterior cerebri totius facies, donec in spinalem medullam abeat, plerumque colore est fubruride cinereo, vel languide rufleo. Fusciora sunt cerebra sanguine ditia, e. g. hominum apoplexia enectorum, vel hominum crassioris sanguinis; pallidissima vero sunt cerebra hydropica vel hominum pituitosorum vel hæmorrhagia mortuorum. Dubio procul color cerebri sanguinis temperaturam sequitur, et ideo pallidius est infantibus, quam adultis.” *Sommerring hum. corp. fab. vol. iv. p. 41.*

† Thus the cineritious substance is mixed with the medullary matter in the corpus callosum, in the corpora striata, the thalami nervorum opticorum, in the tubercula quadrigemina, the imminencia mamillaria; in the crura cerebri; in the pons varolii; in the corpora olivaria, and medulla spinalis.

‡ “E xerampelina sulla superficie del cervello, e dei corpi scanalati quando non evvi aqua nei ventricolo; fosca nei talami de' nervi ottici, e nelle gambe del cervello, dove quà e là suole avere del nericante giallognola zolferina, e talvolta granadiglia, nelle eminence olivari.” *Malacarne, parte ii. sec. 15.*

§ De cinerea cerebri substantia, *Lepsiæ.*

|| *Hist. de l'Acad. Roy. an 1781. p. 507.*

should never have been doubted) has been deduced from its being so generally found towards the origin of the nerves.*

The cineritious substance seems to have a much greater quantity of blood circulating in it than the medullary substance. Its vessels come by two distinct routes, partly from the extremities of those arteries which appear in large branches upon the surface of the brain, and partly by vessels which penetrate through the medullary substance from the base of the brain. Ruysch and Albinus have made the most minute injections of this part of the brain. The former conceived it to consist entirely of vessels; but Vicq d'Azyr and Albinus found always, in their experiments, that a great proportion of it remained colourless after the most minute injection. It is, indeed, very improbable, that so soft a body should be entirely composed of vessels. How, for example, can we suppose the commissura mollis, or cineritious matter, on the sides and bottom of the third ventricle, or the almost transparent lamina, which we find in some parts, to be composed of vessels?

The white MEDULLARY SUBSTANCE appears to be a pulpy mass. We observe no peculiarity of structure in it towards the surface of the brain, where it is contiguous to the cortical matter; but towards the origin of the nerves it takes a more fibrous appearance. This appearance of fibres is not owing to any peculiarity in the medullary matter, but to the manner in which the pia mater involves it. The medullary matter, being chiefly internal, has every where through the brain a communication from the fore to the back part, from the upper part to the base: from the great central part it extends in form of striæ, into the corpora striata and thalami; it invests the eminences in the lateral ventricles; and those upper parts have communication with the medullary substance of the base.

M. Meckel found, upon comparing the brains of an European and of a negro, that the medullary matter differed very much in colour. In the negro, instead of the whiteness of the European, the medullary matter was of a yellow colour, and nearly like the cineritious matter: he observed also, that this very peculiar distinction of colour was only to be observed

* Il faut que les usages de la substance grise soient tres-importans; car independamment de la portion de cette substance que les circonvolutions contiennent, et qui semble appartenir à la masse blanche du cerveau, on ou observe des amas plus ou moins considerables pres des diverses origines des nerfs: ainsi pres de la premiere et la deuxieme paire, sont les corps striés et les couches optiques; la troisieme paire est pres d'un espece noiratre que je decrirai ailleurs; la quatrième paire fort au deffous des tubercules quadrijumcanx, dont le noyau est composé de substance grise, la cinquieme, la sixieme, la septieme, se trouvent aux environs de le protuberance annulaire, ou la substance grise est mêlée avec la blanche; la huitieme et la neuvieme sont placées pres de l'eminence olivaire, où j'ai observé un mélange particulier de substance grise. Mem. de l'Acad. Scienc. an 1781, p. 507.

when the section was recently made, and that the darker colour of the medullary matter became fainter when exposed to the air.*

OF THE OBSERVATIONS MADE UPON THE MINUTE STRUCTURE OF THE BRAIN.

THE opinions regarding the structure of the brain have had a dependence on the general doctrines of the structure of other secreting organs, and it is, of course, connected with the disputations of Malpighi and Ruysch, because the doctrine of the glandular nature of the brain, and the belief of the nervous fluid being a secretion, has, in all ages, formed the basis of the most favourite theories.†

Malpighi found, on throwing in black and fluid injection, that there remained always particles colourless, and to which the injection did not penetrate. He conceived these to be glandular follicles, and that the cineritious substance of the brain consisted of this follicular or glandular structure, while the medullary matter of the brain was merely the fibrillæ of the excretory duct. This opinion was founded on conjecture, with but a very poor shew of experiments, viz. by boiling the substance of the brain in oil, he found it take a granulated appearance, as if formed of small grains, or little glands.‡

Such was the received opinion until Ruysch, with a despotic authority, swayed the opinions of physiologists: he alleged, in proof only his own experiments and preparations, in which other anatomists could not follow nor refute him, and therefore

* "La moelle du negre etoit d'un jaune clair, tirant un peu sur le gris, tandis que celle de l'Europeen etoit d'une parfaite blancheur." "Celui du negre etoit d'un jaune noiratre et celui de l'Europeen d'une couleur blanche—Prolongeant ensuite la dissection jusqu' aux grands ventricules du cerveau j'ai coupé horizontalement les corps striés et les couches des nerfs optiques. C'est là où la difference a paru vraiment etonnante, le corps strié dans le negre étant presque de la couleur brune d'une ecorce d'arbre, au lieu que celui de l'Europeen etoit couleur de chair pale tirant au cendre," &c.

† Indeed this doctrine of the glandular nature of the brain has descended from Hippocrates—"Caput quoque ipsum glandulas habet cerebrum enim est ut glandulæ album est et friabile," &c.

‡ "Pedamentum, supra quod posita est philia in qua conservatur portio cerebri in liquore, quam decoxi in oleo olivarum per horas, sicuti, facere affolet Dr. Vicussens. Ea autem plane *mutilis et perversa est preparatis*, nam nihilum quidem vasculosi visui occurrit post decoctionem in dicto oleo, et quod unusquisque tentare potest ita ut inventor neutiquam habendus sit Dr. Vicussens Sc. quod cerebri cortex nil sit, nisi extremitates vasorum sanguinorum: in ea autem nemo hæcenus (quod sciam) me imitari poterit aut analogum quid fecit." Ruysch Thes. An. x. No. xxxii.

they acquiesced. His most unanswerable and most insulting argument was "veni et vide.*"

According to Ruysch, the cortical substance of the brain is entirely vascular, and has no appearance of a glandular or follicular structure; nay, he conceived it to be entirely composed of arteries.† But as Malacarne observes, though we suppose the extremities of the arteries of the cineritious substance to be more minute than those which are distributed to the microscopical corpusculi of the smallest visible insect, there must still remain some part, which is not composed of vessels; and in regard to the veins of the cineritious substance we may appeal to Albinus, who, from the substance of the brain, finds many veins connected with the arteries of the cineritious substance when he carefully lifts the pia mater. But there is this peculiarity in the distribution of the blood vessels of the brain, that, though the cineritious substance be the most vascular, yet, in the medullary matter, we see the vessels with large open mouths, and more distinct than in the cineritious substance. In following the blood vessels from the base of the brain into the medullary substance, we see them distinct, and of considerable magnitude; but when they are about to enter the cineritious substance, they disperse into minute branches ‡ In the same manner those arteries, which are carried into the sulci of the surface by the pia mater, branch into extreme minuteness before they finally penetrate the cineritious substance.§

Leeuwenhoeck|| observed, in the cortical substance of the brain, a pellucid, crystalline, and to appearance oily matter; he calls this, therefore, the substantia vitrea. When he had put a small portion of this under his glass, he saw a fluid,

* "Milites quando hostium adventum audiunt, clamant ad arma! ad arma! sic ego dico hic ad visum! ad visum!" Responso ad J. Ch. Bohlium.

† Vieussens was latterly of the same opinion, and is accused of plagiarism by Ruysch. Accordingly, we find, that in some parts of his works he describes the glands and ducts of Malpighi.

‡ Leeuwenhoeck saw, in the substance of the brain, but especially in the cortical substance, red blood vessels, but so delicate, that he could not comprehend how the globules of the red blood could pass along them; and what appeared more particular, they were of a deeper colour than the red particles themselves: for, when seen singly, they appeared to have very little colour. This he explained by an experiment made upon a certain little animal. After it had sucked blood very plentifully, he observed, that the blood was broken down by digestion, and conveyed through the limbs and horns of the creature, so as to make it universally red. So here he conceives that the globules of the blood may be broken down and altered in their shape to enter the minute vessels of the brain.

§ Malacarne, Part II. sect. 18.

|| He was born in Delft, in Holland, 1632, and died 1723. He is celebrated for his microscopical discoveries; his papers are chiefly in the Transactions of the Royal Society of London, about the year 1674.

which he at first conceived might have escaped from the globules that were necessarily cut by the knife. This fluid also he found to consist of very minute globules, thirty-six times less than those of the blood.* These small globules he conceived to have probably constituted a fluid, which, during the life of the animal, was moveable, and in vessels, though now in death congealed and fixed.† The colour of the cortical substance he found to depend upon the minute ramification of the vessels which were of a dark brown colour, while, in the medullary part, they were clearer and more transparent. Independently of this distinction of vessels, he could observe little difference in the medullary and cineritious substance; the refraction of the rays of light amongst the transparent globules being the cause of the whiteness of the former.

R. della Torre, in his microscopical observations, describes globuli in the brain; he says, that he saw them floating in a pellucid viscous fluid. But Prochaska‡ thinks Della Torre must be mistaken in this, for when he took a small portion of the brain, he saw it consisting of innumerable globules, which continued to adhere to each other, even after three months maceration in water: and thence he concludes, that it could not be as R. della Torre conceived, that these spherical bodies move from the brain on towards the extremities of the nerves; nor do these bodies lie imbedded in a glutinous fluid (he continues) but they are connected by the extremely minute and pellucid sepimentæ of the pia mater, and by the vessels which pervade both the cortical and medullary matter, and which nourish as well as support and connect these corpusculi.

Prochaska cannot, from his own observations, determine whether these globular bodies be convoluted vessels, or what they are. R. della Torre had observed, that they were largest in the cortical part, less in the medullary substance, still diminishing in the medulla oblongata, and least of all in the nerves; but succeeding observation did not support this assertion.§ Malacarne expresses himself to be nearly of the same opinion in regard to the vesicular structure of the cortical substance of the brain. The minute processes of the pia mater, says he, embrace and support the medullary substance, which

* Anatomica Contemplatio, 30.

† Among those globules, of which the brain is composed, he saw also globules of the blood, which it was easy to distinguish by their roundness. These red globules, he supposes, had escaped in consequence of the minute vessels having been cut by the knife.

‡ Tract. Anatom. de Struct. Nervorum.

§ This was certainly a theoretical deception; it is like the accurate observation of Tracassati, who could distinguish a difference of taste in the medullary and cineritious substance of the brain.

is surrounded with a matter of a darker colour, and less distinctly fibrous, but not less essential, and which is composed of corpuscles, that, in figure and arrangement, resemble the vesicles of the pulp of a lemon.*

Many authors endeavour to support their conjectures regarding this vesicular structure of the brain by morbid dissection.† We see the brain frequently degenerated into hydatids, or into little vessels, or into knobular glandular-like schirrosities. I have seen this vesicular appearance in great portions of the pia mater. I have seen the pia mater with innumerable little bodies like miliary glands upon it; and also the whole upper and external part of the brain degenerated into one mass of disease. It was hard, schirrous, tuberculated, and like a diseased gland.‡ But I cannot conceive that any conclusion, in regard to the natural structure of the brain, can be drawn from such appearances. They are to be considered as the diseases of the vessels and membranes rather than of the peculiar matter of the brain.

When the brain is examined in the fœtus of the early months, although the substance of the brain is extremely soft, and even of a fluid consistence, the membranes and vessels are fully formed, exquisitely minute, and perfect in all their processes, so that they give form and firmness to the brain. We see, consequently, that the due increase and complete organization of the brain is a gradual process, and like the growth of the other parts of the body.

OF THE SENSIBILITY OF THE SUBSTANCE OF THE BRAIN.

It cannot but appear strange, that the very source or centre, to which every sensation is referred, should itself be destitute of sensation; yet, we are assured, by the experiments of Haller and Zinn, that the cortical substance of the brain has been irritated, without the animal being convulsed, or giving signs of pain; § but when the medullary part of the brain is irritated, the effects are instantaneous, and the animal is convulsed. It has been observed, that as the injury of a nerve causes convul-

* Malacarne, page 2. sect. 4.

† Wepfer de cicuta aquatica. Mangetus.—Malacarne, &c.

‡ There has been observed a structure like the bronchial gland. Huber, *Observationes Anatom.—Acta Helvetica*, 1758. Tom. iii.

§ But, like the insensible membranes, it becomes irritable by disease; or by pressure, which affects the universal function of the brain. Vander Linden, in his *Medicina Physiologica* (1613,) brings proof of the insensibility of the brain.—See the general enumeration of the effects of wounds in the brain. Haller *Physiol.* Tom. iv. &c. *Observations par M. de la Peyronnie de decouvrir la partie de cerveau ou l'ame exerce les fonctions.—Acad. Roy. des Sciences.*

sions, so does that of the central parts of the brain, from which the nerves originate ; but this sensibility* diminishes towards the surface of the brain.† We see a distinction betwixt the structure and function of the nerves and of the brain ; or rather betwixt the cineritious substance of the brain and the nerves. For, although we must necessarily conclude, that the cineritious substance is an important and, perhaps, the most essential part of the system, still it does not evince, by the immediate effect of injuries, that strict sympathy and universal connection which belong to the nerves.

The nearer to its source that a nerve is pricked the greater is the effect of the injury. As it recedes from its origin towards the superficies of the brain, the effect is lessened, because the connections of the part are diminished in number, proportionally to their distance from the central parts of the brain ; a puncture in the centre injures more filaments from their being concentrated to form nerves.

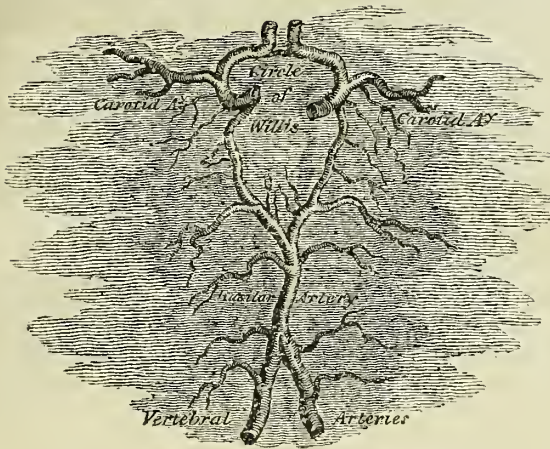
Several ounces of the brain have been lost in consequence of wounds, without death, or loss of memory, or intellect.

There is a very marked distinction betwixt puncturing, cutting, or even burning, the surface of the brain, and pressing it. In the first there is little or no effect, or even pain. In the latter there is stupor, pain, or convulsions. The reason is, that in the first it is a local irritation in a place which has little, if any, feeling, while in the latter, the effect of the pressure spreads extensively.

No sensible man will expect, in the most minute and unwearyed investigation of the structure of the brain, to find the explanation of its function. It is interesting to find effects so peculiarly connected with the operations of the mind, depending upon a structure of so gross and animal a nature as this of the brain, so far as we have seen ; but still, all explanation of those operations must be visionary.

* It is an effect different from pain or sensation : it shakes the body with violent convulsions.

† Sommering. tom. iv.



CHAP. II.

OF THE VEINS AND SINUSES OF THE BRAIN.

THE brain is very profusely supplied with blood, in so much, that the blood has been supposed to circulate in the brain in a proportion four times greater than in any other part of the body. This is the most moderate calculation, and it has been formed from a comparison of the quantity of blood circulating in the head, with that which circulates in the arm. Boerhaave and Kiel, comparing the area of the arteries of the cerebrum with that of the ascending aorta, made a most erroneous calculation of the proportion of blood circulating in the brain, compared with that of the rest of the body. Had they compared the quantity of blood within the head with that of the lungs, of the liver, of the spleen, or of the kidney, the difference would have been less striking.

Wherever there is great arterial vascularity, we are sure to find also peculiarities in the venous system of the part; wherever we find an accumulation of tortuous arteries passing to a gland, we shall also find the veins tortuous and large; or wherever the arteries of a part take a diseased action, the effect of this action will be found most perceptible in the change which the veins undergo. In short, the effect of disease is

much more surely to be discovered in the venous than in the arterial system; and no where is this better exemplified than in the brain.

The following appear on the first view to be the most striking peculiarities in the veins of the brain; their size; the little connection they seem to have with the surrounding cellular membrane; and the inconsiderable support which they appear to receive from it; their having no valves; their being in their course distinct from the arteries; and lastly, their not being gathered into great trunks, but emptying themselves into the sinuses of the dura mater.

It is not easy to conceive how the veins of the brain should have been so much overlooked by the older anatomists; but from the dissections of Albinus, and the microscopical observations of Leeuwenhoek, we have authority for what is, perhaps, in itself sufficiently evident, that the veins of the surface of the brain are derived from minute ramifications conveyed in the delicate pia mater; and that these, as in the other parts of the body, proceed from the extremities of the arteries, without any apparent peculiarity in the connection betwixt the extremities of the arteries and the veins of the brain.*

The description of the veins of the brain, previous to their entering the sinus, has been neglected. I divide them into the external and internal veins of the brain, or those which emerge from its substance, and are seen upon the surface; and those which, coming chiefly from the sides of the ventricles, are convoluted in the plexus choroides, and terminate in the fourth sinus.

OF THE VEINS WHICH ARE SEEN UPON THE SURFACE OF THE BRAIN.

Vicq d'Azyr has been minute in his attention to the veins of the surface of the brain. He confirmed the observation, that almost all the veins which pass into the longitudinal sinus, open in a direction contrary to the stream of blood in the sinus. ‡ These superficial veins of the surface of the hemispheres,

* The observation is trivial! but we must recollect, that Vesalius contradicted Galen, and affirmed, that the sinuses received also arteries which gave them their pulsation. This opinion was refuted by Fallopius, but adopted by Vieussens, Wepfer, and others, upon the idea of the facility with which injection passes from the arteries into the sinuses; while, on the other hand, Ruyfch conceived that the cortical part of the brain consisted entirely of arteries.

‡ From Vicq d'Azyr's table we should be led to conclude, that the veins did not decidedly all open with their mouths opposed to the stream of blood. Ridley asserts, that one half open backwards. Santorini also observes great variation in the direction of these veins. Lower, while he observed this direction back-

are in number generally from ten to fifteen on each side.— They really do not seem to be worthy of the minute attention which Vicq d’Azyr has bestowed upon them ; he has most carefully described each individual branch, and that not in general terms, but first those of the right, and then those of the left side. Now, although these veins do not enter the sinus opposed to each other, nor in pairs, still the irregularity is trifling, and were it important, does not admit of description.— Those veins do not lie in the sulci of the brain, but pass occasionally along the interstices, or over the convolutions of the brain ; they take in general a course from before backwards, but previous to their entering the sinus, are turned forwards. We have already observed, that the pia mater and dura mater have no connection, but at the place where those veins enter the lamina of the dura mater ; and here their connection is somewhat peculiar. It is not a simple adhesion of the pia mater and dura mater ; but a white spongy substance seems to connect and strengthen them, and, when torn asunder, it leaves a soft fatty kind of roughness upon the pia mater. These appear to me to be the same bodies which Ruysch so frequently mentions as little particles of fat, and which others have taken to be the glands of the pia mater.* Vicq d’Azyr, in his xxxiiiid plate, fig. 14, has confounded them under the name of the glandulæ Pacchioni.† Of these veins lying upon the surface of the brain, there is one, or very often there are two large veins on each side, and which enter generally pretty far back in the sinus, and are somewhat peculiar from their greater size, and their semicircular course. These, from their state of dilatation, and the colour and fluidity of their blood, will be

wards, describes them, at the same time, as passing obliquely betwixt the coats, like the gall duct in the intestine, or the ureters into the bladder. Sabbatier says decidedly, that they enter with their mouths opposed to the course of the blood in the sinus. From Malacarne, we should be led to conceive (what I believe to be the truth) that they open very irregularly. “ Non tutte queste vene sboccano obliquamente ad un modo nel seno, come non a tutte la membrana interna del medesimo somministra quella valvuletta, che pure a modi lingua, di briglia, di mezza luna frequentemente ne ottura la meta, il terzo, o minor parte degli orifici.” Malacarne, p. 94.

* “ Portio piæ matris in liquore, cujus superficies exterior obsita variis particulis prominentibus exiguis, quas pro glandulis habuerunt nonnulli : cum autem sint diversæ formæ, et colore pinguidinem repræsentent, pro pinguidine potius illas habeo præfertim cum inter duplicaturam piæ matris aliquoties pinguidinem invenirim.” Thefaurus Anat. ix. No. xlii. Epist. ix. p. 8. Thes. v. No. 1.

† We see also what he says in the Acad. of Sciences. An. 1781 p. 502. “ Elles étoient plus ou moins recourvées, vers leur insertion par les glandules de Pacchioni ; les ayant examinés dans plusieurs sujets, j’ai observé qu’elles étoient à peupres, de chaque côté au nombre de dix, douze, ou quinze.” “ Ridley calls these carnos adnescences,” betwixt the membranes, p. 8. As to the gland which Willis affirms to be scattered over the tunica arachnoïdes, I could never see them.— Ridley.

found in morbid dissection, to mark sufficiently, in many instances, the character of the venous system of the brain. There is again another vein somewhat peculiar in its course: whilst those take a superficial course, and are upon the level of the longitudinal sinus, it gathers its branches upon the internal flat surface of the left hemisphere, and rises so as to insinuate itself into the inferior part of the sinus.* All these veins of the surface of the cerebrum have very free inosculation with each other.

I cannot any where better observe the negligence of authors, in regard to the glandulæ Pacchioni, than when speaking of the mouths of those veins which open into the great longitudinal sinus.

I cannot help thinking, that many of our best authors have overlooked entirely the importance of the glandulæ Pacchioni; and many also have been entirely ignorant of them. We have already mentioned, that a few small bodies by no means constant nor regular, were to be seen upon the external surface of the dura mater, in the course of the longitudinal sinus, or at no great distance from it. We have mentioned also those fatty-like adhesions of the roots of the veins as they enter the sinus, and which rather belong to the pia mater. Both these are called the glandulæ Pacchioni improperly. The bodies which engaged Pacchioni and Fautonus in such violent disputes, are seen on the inside of the longitudinal sinus, and are connected with the opening of the veins†; they appear of a fleshy colour, projecting like papillæ, or like the granulations of a sore. Pacchioni says, "Ovorum instar bombycinorum apparent," which describes their conglobate appearance; but they are of a pale fleshy colour, which Pacchioni says is owing to their being surrounded with muscular fibres. I have added the plate of Pacchioni, and contrasted it with a more natural drawing of them. The preparation from which Pac-

* Vicq d'Azyr.

† "In longitudinali sinu, immediate, sub membranosis expansionibus, in areolis chordarum Willisianarum, quin et supra easdem chordas consistæ sunt innumeræ glandulæ conglobatæ, propria, et tenuissima membrana, veluti in sacco conclusæ; quæ racematim ut plurimum coeunt; raro sparsim disponiuntur: hæc glandulæ utrinque ad latera falcis mesoriz, ab ejusdem apice ad basis usque posticam partem miro prope modum artificio procedentes, dorso lacertorum accumbunt, & partim ab horum fibris, partim ab iis, quæ a chordis emergunt, firmantur, atque invicem alligantur, ita ut non nisi lacerat acu disjungi possint." Vide Pacchioni, p. 126.

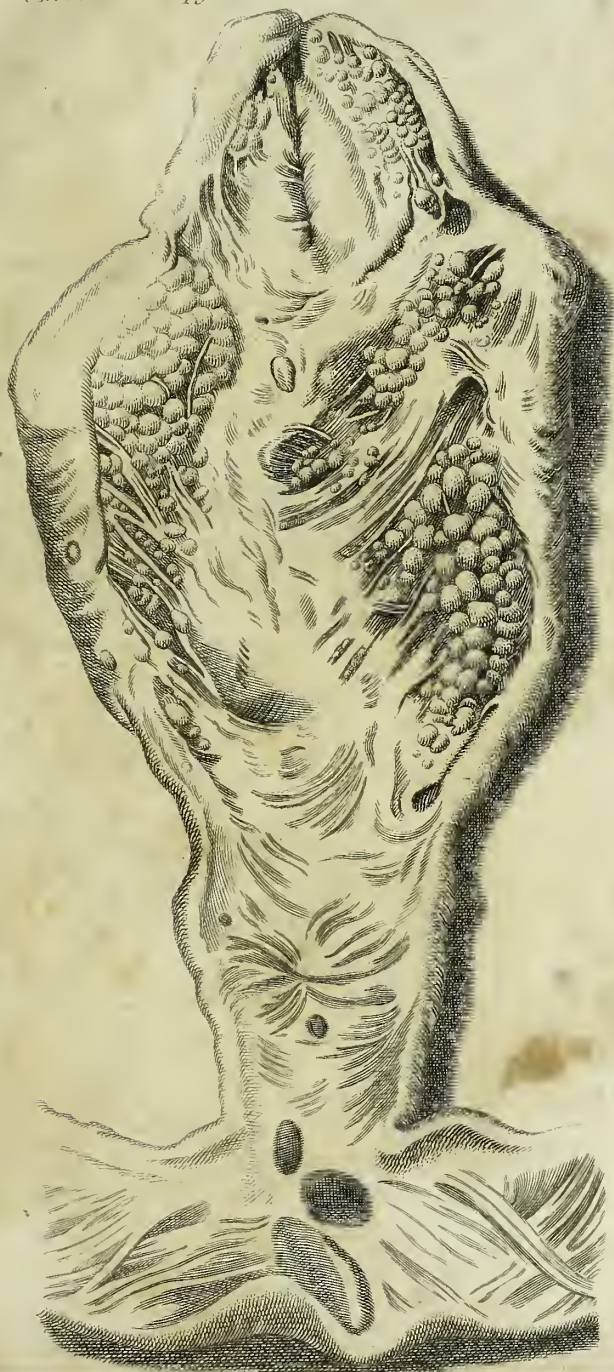
"Sinu longitudinali aperto, in conspectum veniunt corpuscula rotunda, & subrotunda, mili forma, (a clariss. viro Pacchione detecta) hæc magnitudinem aciculæ vulgaris caput haud superant, nisi per microscopium introspectantur, aut ex duobus corpusculis combinentur." Ruyfch, Thes. vii. No. xxxiv. From this we see how various the size of these bodies is. In the next paragraph he observes, "Vix et ne vix quidem ullum ex dictis corpusculis videre potest."



The Longitudinal Sinus laid open & the Glandular Pacchioni seen



An accurate Copy of Pacchioni's Plate of the Glands.





chioni had taken his plate, was previously macerated in vinegar. These bodies being soft and vascular, have allowed the minute injection to transude in some of the experiments of anatomists, which has given rise to the opinion of the actual communication of the arteries of the dura mater with the sinuses. As to their use,* I am in considerable doubt. Joan. Fautonus (in his letters to Pacchioni) conceives that they give out a fluid into the sinus, to dilute the venous blood.† Pacchioni describes ducts passing from them to the pia mater, (which are those connections that we have already remarked,) and conceives that they lubricate the surface, or communicate with the substance of the brain; and that they are pressed, and their secretion promoted by the motion of the chordæ Willisianæ, and the action of the dura mater.‡

I should rather conceive that they had a valvular action on the mouths of the veins; they project from the mouths of the veins into the sinus, and the blood passing from the veins must filter through them, and be checked in its retrograde course, and perhaps obstructed in its natural course when they are enlarged. As these bodies differ very much in the variety of subjects, they must sometimes impede the free egress of the blood from the veins of the cerebrum into the longitudinal sinus, and cause disease, especially as they are softer and larger in old men.§ At all events, they are too much overlooked in morbid dissection.

The veins which answer to the arteria corporis callosi, and which are seen lying upon the corpus callosum in a very fine cellular membrane, rise and pass into the inferior longitudinal sinus, that which is formed in the lamina of the inferior edge of the falx.

* It is curious that these bodies are confined to the longitudinal sinus. "Mirum, & æque animadversione dignum est, hæc glandulas ad folius longitudinalis sinus latera reperiri cum in lateralibus sinibus vel nunquam, vel raro admodum per pauca earundem vestigia adnotentur, ubi præsertim præfati canales deorsum inclinare incipiunt, antequam ab interseptorum dorso discedant." Pacchioni, p. 127.

† "Ego aqueum humorem in glandulis egregari, fluere lympham in tubulis, quos tecum lymphaticos appello, nunquam negaverim, sed liquidi fluxum ab utrisque versus sinum magis quam versus ambitum cerebri verisimilem, magisque naturæ legibus consonum esse affirmo." Fautonus Epist. D. A. Pacch. Oper. Pacch. 177.

‡ "Ex iis autem in minimum quidem vasculum lymphaticum prodire conspiciere potui." Ruysch.

§ "Fibris carneis tenuissimis circumambiuntur singulæ, unde colorem carneo-pallidum nancisci videntur: in senibus vero, in quibus hujusmodi fibræ enervatæ nimis laxantur, et ferme disparent, glandulæ albescentes, & magis turgidæ cernuntur: quod, & in hydrocephalicis, comatosis, & id genus aliis observari posse arbitrarer." Pacchioni Oper. p. 126, 127.

OF THE INTERNAL VEINS OF THE BRAIN, AND OF THE
CHOROID PLEXUS.

Under this title of the internal veins of the brain, the choroid plexus comes naturally to be considered.

The Choroid Plexus and Vena Galeni taken from the Brain and spread so as to show their connection.



1. Choroid Plexus of the right Side, 2. Plexus of the left Side spread out. 3. Arteries to this part, where it lies in the interior horn. 3. Plexus of the 3d. Ventricle formed by the Junction of 1. 2. 5. Vena Galeni.

The most remarkable thing in the ventricles of the brain is, that they have lying in them this very peculiar vascular structure, the choroid plexus. The lining membrane of these cavities is extremely thin and smooth, insomuch, that some anatomists have denied its existence; but through the whole ventricle there run certain folds or plaits of this membrane, which are so loaded with vessels as to resemble a fleshy substance, and to lose altogether their resemblance of the lining membrane. The plaits, before they are unravelled, look like masses of tortuous vessels, lying loose and unconnected in the bottom of the ventricles.

The largest portion of each plexus choroides comes up from the posterior prolongation of the lateral ventricles; they then run forwards. In each ventricle they lie in the groove, betwixt the thalamus nervi optici and corpus striatum; and cover the tenia semicircularis geminum. These two plexus of the lateral ventricles unite under the anterior crus of the fornix,

and form a small plexus, which is continued upon the inferior surface of the velum interpositum, and even into the third ventricle. Again, there is a plexus which lies in the fourth ventricle. Vicq d'Azyr also describes, as occasionally occurring, little insulated plexus attached to the veins, branching on the corpora striata.* Thus each division of the brain has its choroid plexus.

These vascular webs must have an important use. I should conceive that they chiefly secreted the fluids of the ventricle; for I believe the tortuosity to be the most unequivocal mark of the activity of its vessels. This opinion, however, is nothing new.† Another prevailing idea was, that the blood accumulated in these convoluted vessels occasioned such a gentle continued heat as favoured the circulation of the spirits through the cavities of the brain, and preserved the fluidity of the water of the ventricle.‡ Great variety of opinions have prevailed regarding the structure of those bodies. We see them consisting of knots of convoluted vessels; chiefly veins; or these at least are most evident from their size, and the colour of their blood. These convolutions of vessels are by many good anatomists described as glands. Varolius, Sylvius, Wharthon, Willis, Santorini, and Lieutaud, consider them as such.§ Three sets of ARTERIES pass up to the PLEXUS CHOROIDES, from the base betwixt the crura of the brain; they come, 1st, from the curve of the internal carotid artery; 2d, from the communication betwixt the basilar and carotid artery; 3d, from the basilar artery, and most posterior part of the branch of communication. These arteries, which are small,

“Sur le côté des ventricules latéraux, j'ai quelquefois observé de petits plexus choroides isolés, que accompagnoient quelquesuns de ces rameaux des veins de Galien, que l'on voit passer sous le tænia femicircularis, & s'étendra sur le corps strié.” Vicq d'Azyr Memoir, l'Acad. Roy. 1781, p. 540.

† The supposed glands of the plexus choroides were conceived to secrete the fluid of the ventricles. Where the plexus lies upon the posterior crura of the fornix, it is often diseased, having knots like glands, or, being raised into vesicles, like hydatids. “Eas bullas humorem ventriculorum secernere olim conjectura fuit. Verum vitio cum nascantur vix perpetuum habitum generare idoneæ erunt.” Haller, tom. iv. 48.

‡ See Duvernèy, tom i. p. 55. “Ut enim sanguis intra sinuum cavitates aggestus, Balnei calidioris vicem prestat, quo spiritus animales in extima & corticali cerebri parte uberius distillentur: ita sanguis intra plexus hujus vasa exilia contentus, quo iidem spiritus in penitiori ac medullari substantia idonee circulentur, Balnei minoris, & magis temperati loco esse videtur.” Willis Cerebri Anat. p. 47.

§ Galen gives a good description of the choroid plexus; he describes the innumerable veins of which it is composed, and their joining the fourth sinus by the vein which retains his name. Some have confused themselves with a passage of Ruyfch. Thes. iii. No. lxxv. &c. in which he is speaking of the choroid plexus, where it appears in the base of the skull, from the bottom of the fourth ventricle. They have understood him to say, that the plexus was covered not with the pia mater, but with the tunica arachnoïdes.

are convoluted into great minuteness* in the membrane, and their blood is returned by veins, which taking a very tortuous course, seem to entangle their branches, and form a mesh of veins.

The blood of the two plexus of the lateral ventricles, and that of the third, is conveyed into the velum interpositum, or that membrane which stretches under the fornix, and over the third ventricle. The branches of veins also which extend themselves upon the sides of the lateral ventricles, and into the processus digitalis, being gathered together upon this membrane, open into the vena galeni, or rather form it.

The most remarkable branches of veins in the lateral ventricle are these: a considerable branch is seen to collect its branches upon the anterior part of the ventricle, and in the anterior sinus, or horn of the ventricle. This vein runs back towards the anterior crus of the fornix, and dips under it, just above the communication of the ventricles; and joins the veins in the velum of Haller. Other small veins are seen collecting their branches upon the corpora striata; and passing under the centrum semicirculare geminum, connect themselves with the plexus. Again several branches of veins are extended in the posterior part of the ventricle. These are from the medullary substance of the posterior lobe of the cerebrum. They pass under the posterior crus of the fornix and join the vena galeni. Lastly a vein remarkably tortuous, frequently full of blood, passes forward and is seen at intervals in the plexus choroides. This vein taking an acute turn, joins its fellow under the anterior crura of the fornix and is reflected backwards and under the fornix, so as to form the beginning of the vena galeni.

The *VENA GALENI* then is the great central vein of the brain. It stretches from the extremity of the fourth sinus into the internal part of the brain, to receive the blood from the membrane lining the ventricles,—from the substance of the brain,—from the plexus choroides,—and from the velum interpositum.† It lies under the posterior part of the corpus callosum, under the fornix and above the nates and testes. It is entangled in the velum itself. It consists of two great branches which lie parallel to each other, and which sometimes have the

* “Huncce plexum nil esse nisi arteriolas, ad visum succofas, a naturali constitutione arteriosa non nihil recedentes, mirumque in modum contortas, serpentinoque modo reptantes, glandulasque representantes.” Ruyfch, Thes. v. Affer. quartus No. lxxviii. Not. 2.

† The velum lying upon the nates, and testes, and adhering to them and the pineal gland, the vena galeni receives here also veins from those bodies, and from the upper part of the cerebellum.

appearance of being twisted, and these unite before they enter the fourth or straight sinus.

In the BASIS of the BRAIN the veins are not remarkable nor do they require any description distinct from the sinuses into which they open.

They are small, having little way to run; and before they become large trunks, they empty themselves into the numerous lesser sinuses betwixt the dura mater and base of the scull.— This is perhaps a provision against the pressure of the brain. In passing into those sinuses, the veins take a long oblique course betwixt the lamellæ of the dura mater; which has given occasion to anatomists to describe many intricate lesser sinuses.

OF THE PARTICULAR SINUSES.

Although by the term sinus we are to understand the great veins of the brain, yet as having some circumstances peculiar to them, it is well to distinguish them by a distinct appellation.

SUPERIOR LONGITUDINAL SINUS.

This is a triangular channel, running in the falx from the crista galli of the æthmoid bone to the crucial ridge of the occipital bone. It is not constant in its origin. Sometimes it begins from a blind foramen before the crista galli.* Sometimes from the orbital sinus.† In some subjects it begins only opposite to the fontanelle, or even further back, and then at once swells out to a large size.

As the sinus passes backwards it is gradually enlarging for the reception of the veins from the surface of the cerebrum.— As we have already demonstrated by the marginal plate of the section of the longitudinal sinus (page 12,) the base of the angle is curved, answering to a sulcus, which runs in all the length of the cranium, from the æthmoid bone to the crucial ridge of

* Malacarne, Haller, Gautier.

† These sinuses as frequently are continued into the inferior longitudinal sinus or into the circular or elliptical sinus; they are like azure streaks under the dura mater, covering the orbital process. “Molti fra i voti bislunghi, ovali, tondi, irregolari, che si vidono all’ angolo inferior del seno L. S. Sono caverne cieche o le une colle altre comunicanti lasciate dai già descritti fasci della fibrosa, senza che ad esse giunga vaso aliuno.” Malacarne, p. 94.

“Hæ cellulæ ab exposito sinu ad verticem usque, uberiores, atque magis amplæ perspiciuntur, et inæqualiter hinc inde locantur; ipsarum plurimæ vacuæ sunt habentque orificia in oppositas quasi partes hiantia; membrania circumtegentur quæ est inftar valvulæ semilunaris, totam tamen cavitatem non occludentis; reliquæ vero faveolas tantummodo impervias representant.” Pacchioni, p. 124.

the occipital bone. The lateral planes are drawn tense and converge into an acute point ; the angle formed by the splitting of the internal layers of the dura mater, is strengthened by strong slips of fibres, which upon the inside of the sinus have the effect of making it irregular, and in some degree having the appearance of cells, into some of which cells the probe enters, and leads to the veins on the surface of the brain ; others are blind, or lead to lesser sinuses, which not unfrequently run parallel for some length to the great sinus ; or the probe passes from one of these cells to another. Sometimes, however, the sinus has no such irregularities, but is straight and smooth through its whole length.*

This sinus has in some rare instances been found of a square shape ; its lower surface serving as a roof for another sinus of a triangular form, which, for some way, runs parallel with the great sinus, and which was of course also included in the lamina of the falx—these Malacarne calls *seni subalterni*. Irregular lesser sinuses are by no means uncommon, and they form, sometimes, communications through a great extent of the longitudinal sinus ; or again it will be found that the longitudinal sinus deviates considerably, in some subjects, from the straight line, taking a curve or circle, generally behind the fontanelle ; or it sends off branches, which again unite with it ; or it is fairly divided. In all these cases the chords or fasciculi of the dura mater stretch out over the sinuses, and protect them from compression.

Instead of reaching backwards to the crucial line upon the occipital bone, the longitudinal sinus has been found to divide at the beginning of the lambdoidal suture, and to follow them in a direction towards the petrous bone† while the lateral sinuses, running in the duplicature of the tentorium, were reduced to a very narrow compass.

From the strength of the connections of the sinuses, and from the languid course of the blood through them, I scarcely believe that the sinus has ever suffered the distention, which Malacarne describes in some cases. I should rather suppose that what he mentions had been natural and congenital enlargements ; especially considering that the sinuses, like the other veins of the body, are very apt to be irregular.

* The internal membrane of the sinus is perfectly smooth, and is continued into the coats of the internal jugular veins ; it is of the same nature with the internal coat of the vein.

† Malacarne, part i. 148.

LATERAL SINUSES, OR THE FIRST AND SECOND OF THE ANCIENTS.

The lateral sinuses are formed by the splitting of the lamina of the tentorium, as the longitudinal sinus is by that of the falx. From the crucial ridge of the occipital bone they stretch nearly horizontally; following the connections of the tentorium in a direction toward the petrous bone; then they take a curve downwards and forward, to terminate in the internal jugular vein; passing through the foramen lacerum of the temporal and occipital bones.

Very frequently the one lateral sinus is larger than the other, generally the right is the larger, and sometimes the left is entirely wanting.*

They diverge from the termination of the superior longitudinal sinus at the crucial point of the occipital bone: but sometimes they are irregular, diverging higher, and even passing round in the circle of the posterior part of the cranium, at some distance from the tentorium.†

The right lateral sinus for the most part begins higher than the left. It is generally longer, and may be considered as the continuation of the longitudinal sinus. Nay, in some subjects, the right or left lateral sinus begins from the longitudinal one, while that of the other side is continued from the fourth, or the torcular hierophili; and the lateral sinuses are separated at their origin by a membranous isthmus—if it should happen that the left lateral sinus receives the superior longitudinal one, it would be found to be four times the size of the right; sometimes, also, the longitudinal sinus, turning to the right is continued into the sinus of that side; and the left lateral sinus opens or begins by two or more irregular holes.‡

I have seen a more remarkable variety of the lateral sinuses. The blood which should flow from all those parts of the brain from which the superior and inferior longitudinal sinus, and the vena Galeni, and fourth sinus are derived, seemed, instead of passing by the root of the tentorium, to have forsaken these channels; the lateral sinuses were left diminutive: and the blood had taken a course in the tract of the posterior occipital sinuses, and, after incircling the foramen magnum, it gained its usual outlet.§

* Lieutaud Anat. Hist.

† Malacarne.

‡ See Morgagni Adversaria VI, tab. i. fig. 1.

§ There are instances of the lateral sinuses opening into the external jugular vein.

The angles of the lateral sinuses are strengthened by membranous fasciculi; which pass radiated from point to point, or are confusedly intricated; betwixt these the veins enter as in the longitudinal sinus; where the sinus descends from the level of the tentorium in the angle formed by the occipital and petrous bones, there are many strong irregular fasciculi of fibres: under this point, being no longer protected from compression, by their triangular shape and the tension of the tentorium, the sinuses are irregular; they are now sunk in the sulci of the bones, and the dura mater spreads its sheath over them.

The great irregular cavity,* in which the extremities of the lateral sinuses lie,† and the foramen lacerum, have much variety, and their straightness seems to affect the size of the sinus in its whole length.‡

OF THE INFERIOR LONGITUDINAL SINUS,

The inferior longitudinal sinus, or simply the lesser, or inferior sinus of the falx, runs in that edge of the falx which penetrates betwixt the hemispheres of the cerebrum. It is extremely small towards the fore part of the falx; but, as it passes backwards, it goes on increasing by the accession of veins which come from the hemispheres, and corpus callosum, and from the falx itself. It is formed betwixt the lamina of the falx. Sometimes it runs in its very edge, but as frequently a little way removed from it; sometimes it is found beginning very far back in the falx. The fore part of it is more like a vein running in the falx than a sinus. It is in general to be seen more superficial, and in every respect like a vein, (there being no provision for preserving it from compression) upon one side of the falx. It very often takes a waving course upon the falx; while it receives veins, which branch in the substance of the falx, and form communications betwixt it and the superior longitudinal sinus. It opens into the straight or internal sinus, near the edge of the tentorium.

* Lower conceives that the size of the jugular fossa was the effect of the reflux of the blood; and that the greater size of the sinus of the right side was to be traced to the practice of nurses laying their children chiefly on the right side! See also Morgagni *Adversaria Anat.*

† See Willis *Anatom. Cereb. Hum.* p. 29. and the plate.

‡ Some very large veins open into the lateral sinus; they are derived from the posterior lobes of the cerebrum and cerebellum. These insinuating irregularly betwixt the lamina of the tentorium, and running for some way, have been considered as additional sinuses. See Haller, tom. iv. p. 149.

OF THE INTERNAL, STRAIGHT, OR FOURTH SINUS.*

I would call this the internal sinus, from its situation, but more particularly from its receiving the veins from the internal part of the brain. This sinus is formed chiefly by the vena galeni; which, coming out from betwixt the corpus callosum and tuberculi quadrigemini, enters betwixt the lamina of the middle part of the tentorium, where it is united to the falx; so that by the tension of these two partitions this sinus is drawn into a triangular form, and is as incompressible as those sinuses which run connected with the bone.

It opens, for the most part, by an oval mouth, formed by strong pillars of fibres, into the left lateral sinus, rather than directly in the middle of the communication of the three great sinuses. We shall find this like the other sinuses suffering considerable variety; or irregular smaller sinuses will often be found running betwixt the lamina of the tentorium.

POSTERIOR OCCIPITAL SINUSES.

These are so called in opposition to some irregular and small sinuses, which run upon the occipital bone before the great foramen. THE POSTERIOR OCCIPITAL SINUS lies in the little falx of the cerebellum; it rises upwards, and opens into the common union of the longitudinal and lateral sinuses; it commonly, however, lies rather to the left, and empties itself into the left lateral sinus. It is by no means † constant: like the other lesser sinuses it is subject to great variety; and, before it rises into the tentorium, or empties itself into the larger sinuses, it has a communication or emissarium, by which part of the blood may pass into the external veins, through a foramen in the centre of the occipital bone.‡

THE INFERIOR LATERAL SINUSES.

The inferior lateral sinuses are still more rarely to be found than the last, in so much that Vicq d'Azyr says he never has

* Sinus quartus, Perpendicularis. Haller—The fourth sinus; the two lateral being the first and second, and the longitudinal being the third sinus.

† Vicq d'Azyr.

‡ Malacarne—This sinus is sometimes double; or it has two branches encircling the posterior margin of the occipital hole; or, as I have already observed, it takes the office of the great superior lateral sinuses, and empties it into the foramina latera; or they communicate with the vertebral veins. See Observations sur un dilatation singulière des sinus occipitaux. Mem. de l'Acad. Roy. Anno 1781, p. 596.

seen them. They run in the lamina, or under the dura mater, of the posterior fossa of the base of the scull; that is the hollow of the occipital bone, which is under the tentorium. They are so irregular that they frequently occur in one or other side only. They communicate with the posterior part of the foramen lacerum; with the posterior petrous sinus or vertebral veins; or lastly they occur as an irregular collection of channels running in the several neighbouring sinuosities.*

We see then that there is a point of union for all these sinuses, which we have not as yet described: we see that the superior longitudinal sinus, the two lateral sinuses, the fourth (and consequently the inferior longitudinal sinus,) and the posterior occipital sinus, unite at the crucial spine of the occipital bone. This is the torcular hierophili, † torcular, lacuna, platea, tertia vena, palmentum, pelvis, laguncula. It was natural that the attention of the ancients should be drawn to this part; for, upon opening this union of the sinuses, we find a large irregular cavity, which seems to be particularly strengthened by these strong fasciculi of fibres, which form the support of the sinuses. ‡ Ignorant of the circulation, imagining that the blood ascended by the great jugular veins to the lateral sinus, and seeing that the lateral sinuses opened into this central cavity, they conceived that the blood destined for the brain underwent an operation there, and was thence sent through every part of the brain.§

* “*Independente dai seni lateralia inferiori ho veduta tra le robuste lamine e le fibre, dalle quali incomincia crassissimo l'imbuto vertebrale intorno al maggior foro del cranio una quantita di caverne, de cellule communicanti insieme, le quali formavano un seno cercolare irregolarissimo appoggiato sulla parte superiore, o sul margine interno del foro medesimo.*” Malacarne, p. 113, 114.

† Herophilus was a Greek physician, and disciple of Praxagoras, and contemporary with Erasistratus.

‡ “*Deinde et illia per sectionem scalpelli injiciens, sursum adigere conoberis ad usque verticem ubi venæ duæ invicem congreduuntur; quam regionem Herophilus nominat lenon, torcular Galen. Lib. Nonus de Cerebri, &c. Dissectione.*”

* “*Cocuntes autem in vertice capitis, quæ sanguinem deducunt meningis duplicaturæ, in locum quendam vacuum quasi cisternam (quem sane ob id ipsum Herophilus torcular solet nominare,) inde velut ab arce quadam omnibus subiectis partibus rivis mittunt; quorum numerum nemo facile dixerit, quod partium nutriendarum numerus sit infinitus. Manant autem rivorum nonnulli quidem ex medio ipso loco in totum cerebellum, secti, ac derivati, eodem prorsus modo, quo ii qui in areolis, alii autem ex parte anteriore feruntur, ea scilicet qua torcular excipit dixeris utique velut rivum quendam sanguinis, quem et ipsum ex crassa meninge admodum ingeniose fabricata est, partibus enim ipsius meningis quæ sanguinem duxerunt ad torcular appulsis, dimissaque illinc aliqua in partes subiectas, non amplius, quod superarat, uni venæ concredidit, sed præterea ex crassa meningis partibus anterioribus extensis rivulum efficit, ex quo primum multos rivulos per totam viam produxit.*” Galen, cap. vi. *de torcular.* *Et quo pacto venæ intra cerebrum distribuantur.*

OF THE LESSER SINUSES IN THE BASE OF THE SKULL.

Besides those larger sinuses which we have described, and which convey back the great proportion of blood circulating in the brain, there is a set of lesser sinuses which lurk betwixt the dura mater and the anterior part of the base of the skull. These last are fully more intricate than the others; they lie upon the irregular surface of the sphenoid, temporal, and occipital bones; and tend backwards to the great embouchoir formed by the irregular hole in the temporal and occipital bones.

THE SPHENOIDAL SINUSES.

The SUPERIOR SPHENOIDAL SINUSES are seated in a fold of the dura mater, on the internal margin of the wing of Ingrassias, and before the great wing of the sphenoid bone; they receive the blood in part from the orbit, and from the dura mater; they open into the cavernous sinus, or perhaps into the ophthalmic sinus, which of course, for the most part, conveys the blood into the superior or inferior longitudinal sinus.

The INFERIOR SPHENOIDAL SINUS is very irregular and inconstant. It is in the dura mater, covering the great wing of the sphenoid bone; the blood of this sinus is emptied into the cavernous sinus, or escapes by emissarii into the trunk of the temporal veins.

The ANTERIOR CLYNOID SINUS.—The posterior clynoïd sinus, or elliptic sinus, and the circular sinus, are one and the same; the difference consists only in the manner of describing them; the CIRCULAR SINUS lies within the clynoïd processes of the sphenoid bone, and surrounds the glandula pituitaria.*

As this circular sinus opens upon each side into the cavernous sinus, it is not unaptly divided into two; the anterior half of the circle, being the anterior clynoïd sinus of some author; the posterior half (which is in general wider,) the elliptical or posterior clynoïd sinus, or semilunar.

* Ridley describes it in these words; "Another I discovered by having injected the veins with wax, running round the *pituitary gland* on its upper side, forwardly within a duplicature of the dura mater, backwardly between the dura mater and pia mater, there somewhat loosely stretched over the subjacent gland itself, and laterally in a sort of canal made up of the dura mater above, and the carotid artery on each outside of the gland, which, by being fastened to the dura mater, above and below, at the basis of the skull, leaves only a little interstice betwixt itself and the gland." (*Acuratius tamen a Rilleyo descriptus est. Haller.*)

But Ridley is assuming merit to himself. Brunnerus describes this sinus.

This sinus, like most of the lesser sinuses, is irregular in its shape, its size, its communications, and its origin.* Its natural communication is with the cavernous sinus, which in fact encroaches upon its side; it will be found to communicate also with the sphenoidal sinuses, and the obliqui or petrous sinuses†: at one time the anterior half of the circle is wanting; at another the posterior.‡

THE CAVERNOUS SINUS.

The cavernous sinus is a great irregular centre of communication with the lesser sinuses in the base of the skull. This sinus is sunk upon each side of the sella turcica, and is formed in the irregular splitting of the lamella of the dura mater: it is of triangular shape; it extends from the sides of the sella turcica, even to the foramen spinale.§ The pointed extremity of the tentorium, which extends forwards from the angle of the petrous bone to the posterior clinoid process, covers and protects it. The cavernous sinus is different from all the others; it is an irregular cavity, full of fibrous cords traversing it, which gives it a kind of cellular appearance. It is like a diseased part into which the blood had been driven, till the cellular texture had been distended and partly destroyed. After a minute injection, small arteries are seen to ramify among these fibres; the internal carotid artery rises through it and the sixth pair of nerves is involved in it, in their passage from the skull.

This sinus is the centre of the little sinuses and veins of the anterior part of the base of the brain and cranium: four or five veins pour their blood into it, from the anterior lobes of the brain and the fossa silvii; sometimes, even the ophthalmic veins open into this receptacle.|| The superior and inferior petrous sinuses, and the basilar sinus, open into it behind; the circular before; the sphenoidal sinuses and veins of the

* "Varie sono le origini, e le foci di questo seno. Alcune volte il fonda della fossa pituitaria vi invia due canaletti longitudinali, che scorrono sul dorso di quelle due pieghe sottili falcate ond-*è* tripartita la glandula pituitaria. Altre volte la fossa divisa per traverso da una simil piega che pure ha sul dorso il suo seno, allo elittico lo invia." Malcarne, p. 123.

† Haller, tom. iv. p. 154.

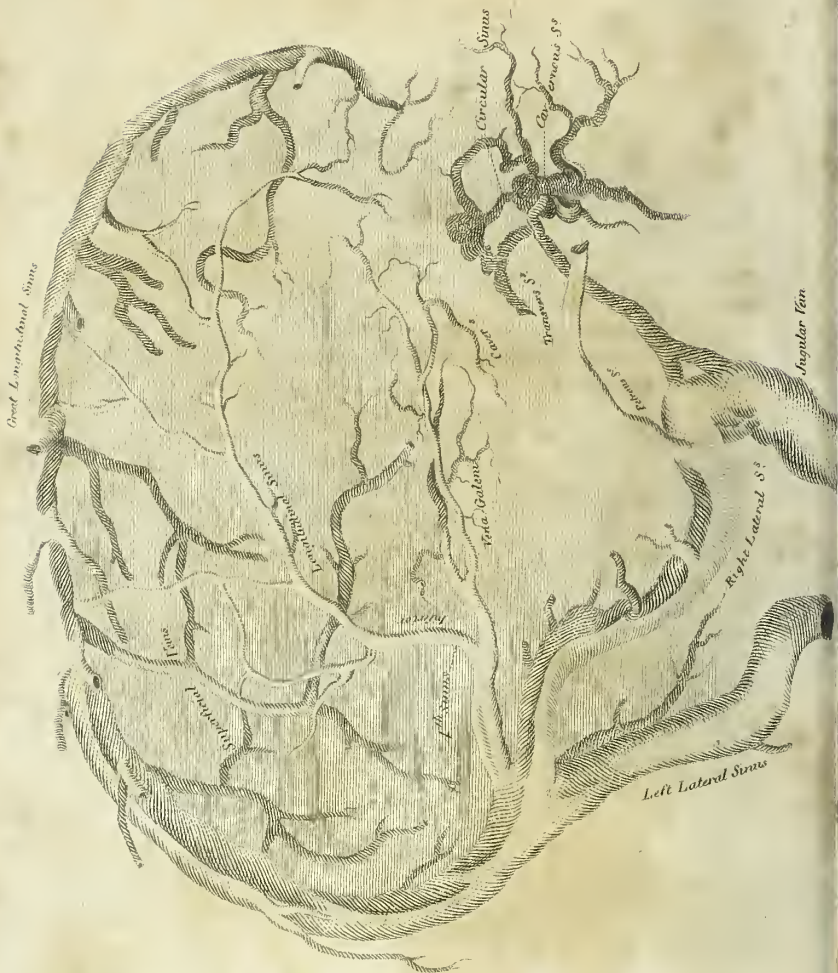
‡ "Nunc anterior nunc posterior ejus arcus amplior est; nunc anterior nunc posterior ejus arcus deficit; nunc totus ipsi desideratur; interdum vere duplicem fuisse, referunt." Sommerring, vol. v. p. 354.

§ Malcarne.

|| This vein, the vena angolana, makes a very remarkable emissaria, but it is more probable that the blood in such veins runs inwards than that it escapes from the skull to the external veins.—Cum venis posterioribus frequentes nexus init. Sommerring, vol. v. p. 354.



Plan of the Sinuses



dura mater upon the side; while the right and left sinuses often communicate by means of the transverse sinus. Besides these the petrous sinuses have several communications, or emissaria as they are called, viz. by the inferior maxillary foramen, the funnel of the carotid artery, through which descends a vein, (the vena sodalis arteriæ carotidæ,) which terminates in the pterygoid plexus of veins, the sphenoidal fissure, the interosseous sinus of Malacarne.*

The TRANSVERSE, OR POSTERIOR CLYNOID SINUS, runs across from one oblique sinus to another behind the posterior clynoïd processes.† In its form it is not peculiar, nor is it very regular.

There are two PETROUS SINUSES, the anterior and posterior, or the inferior and superior sinuses; these two come off nearly together from the cavernous sinus, and running back upon the petrous bone, terminate in the lateral sinuses or beginning of the internal jugular vein; but which two to take as petrous sinuses is a question. For example, Malacarne shows that there is a sinus, by no means uncommon, which belongs as strictly as those others to the petrous portion of the temporal bone.

He calls this new sinus the anterior petrous sinus; and the superior of other writers, he calls the posterior petrous sinus; and the inferior petrous sinus of other writers, as it lies more upon the cuneiform apophysis of the occipital bone, and runs slantingly, he calls the oblique. I would on the contrary consider two of these as the petrous sinuses; the oblique sinuses of Malacarne, as the lateral basilar sinuses; and those which run on the middle of the cuneiform apophysis, as the middle basilar sinuses.

The ANTERIOR PETROUS SINUS runs upon the anterior face of the petrous bone, from near the spinal hole;‡ whence, making a semicircular curve in the angle of the petrous and squamous portions of the temporal bone, it terminates in the lateral sinus.

The POSTERIOR PETROUS SINUS§ lies in that pointed extremity of the tentorium, which stretches forward, connected with the acute angle of the petrous bone. It is narrow; and a sulcus or groove on the angle of the bone gives a partial

* The emissaria 4ta, of Tabarini. Observ. Anatom. p. 42, et. seq.

† In truth the superior, and inferior, or oblique sinus, the cavernous, and the transverse, meet nearly at a point.

‡ And here it has a transverse branch of communication with the cavernous sinus, which runs under the extended point of the tentorium.

§ Or superior petrous sinus. Vicq d'Azyr.

lodgement to it ; it passes from the cavernous sinus to the great lateral sinus.

The LATERAL BASILAR SINUS* is shorter and larger than the last ; and it makes an oblique curve from the cavernous sinus under the pointed extremity of the tentorium, which is continued by the side of the sella turcica, to the termination of the lateral sinus, or rather into the beginning of the jugular vein, by a channel, separated by a bony lamina from the termination of the lateral sinus ; or it is continued into a vein in the base of the cranium, which afterwards joins the great jugular vein.

The MIDDLE BASILAR SINUS. This scarcely deserves the name of sinus. It consists, in general, of a few cellular-like communications, formed in strong fibres of the dura mater, which here partakes of the nature of a ligament. These open into the last mentioned sinus, or sometimes into the vertebral sinus.

The VERTEBRAL SINUSES are veins included in the lamellæ of the dura mater ; and, divided into right and left ; they descend into the tube of the vertebræ, on its fore part, and pass down even to the sacrum. They are connected in all their length with the vertebral, dorsal, and lumbar veins. These sinuses, or veins, at each vertebra, are joined by a transverse branch ; they are connected at the top of the spine with the basilar or anterior occipital sinuses, and with the fossa of the jugular vein.

EMISSARIA SANTORINI.

“*Venæ Emissariæ*” is but another name for those lesser veins which form a communication between the sinuses within the head, and the external veins in the base of the cranium. These, then, are chiefly the ophthalmic, † mastoidean, and vertebral veins. But the *vena sodalis*, *arteriæ carotidæ*, the small vein which penetrates the parietal bone by the side of the sagittal suture, even the *venæ arteriæ meningææ sodales*, and the little veins which pass with some of the nerves, or through the fissures of the bone, are also brought into account. To these a much greater importance has been attached than they merit ; particularly in apoplectic affections of the head, they are sup-

* The inferior petrous, or oblique sinus.

† “ Je me suis convaincu, par des dissections multipliées, que les sinus caverneux et orbitaires communiquent, par un plus grand nombre de veinules, avec les arrières-narines de sorte que les hémorrhagies critiques qui se font par les nez, dans les fièvres aiguës, où le tête est affectée, s'expliquent facilement par ce moyen, ” &c. Vicq d'Azyr, Acad. Royale, 1781, p. 504.

posed to be eminently useful in emptying the surcharged sinuses and veins of the brain into the external veins.

But those lesser passages for the blood, supposing us to be assured that the blood flowed through them, from the sinus to the external veins, are insignificant, when compared with the great outlet of the INTERNAL JUGULAR VEIN; to which we have seen all the sinuses tend. But the accumulation of blood in the vessels of the brain is seldom mechanically produced; it is a disease in the action of the system of the brain, to which we become more and more liable as we advance in years: it is the same gradual change which is operating on the venous system from infancy to old age, that causes this class of diseases of the brain to be peculiar to advanced life.

The importance of the sinuses in the circulation of the blood in the brain, is either vaguely described, or imperfectly understood by authors. We find it said, that the sinuses support the blood against compression, and protect its free circulation. This to me seems an erroneous idea. The lesser veins are as in other parts of the body, and have no such provision; and since, within the head, there can be no such partial compression as in the limbs, any cause which would compress the greater veins, were they not supported, must fall upon their extremities with worse effect. The circulation is the only power which can act mechanically upon the brain; but this can never cause a compression of its veins, because the increased action of the arteries must tend more to the distention of the veins than it will be the occasion of the brain compressing them.

The more general idea conceived of the use of the sinuses is nearer the truth; viz. to prevent the sudden and violent action of the muscles of respiration, or of the muscles of the head and neck, from repelling the blood into the vena cava, or internal jugular veins; and consequently preventing the impulse from being communicated to the blood in the small and tender veins of the brain, which might endanger a rupture of them.* Yet this is not exactly the manner in which the sinuses preserve the lesser veins; they do not suffocate nor take off the force of the impulse from the regurgitating blood, so much as they would do if they were like the trunks of veins in other parts because, being incapable of distention, they throw the undulation of the blood, when it is thus checked in its exit, backwards upon the extremities of the veins. But then the effect is, that no particular vein or trunk receives the shock; all suffer in a lesser degree, and equally, which is their safety. All

* *Monro, Nervous System, p. 4.*

the veins in the base of the brain, which would be liable to rupture, or distention, from receiving, in their sudden turns, the shock of the blood, checked by the muscles of respiration, or otherwise, are preserved by being inclosed in sinuses, and covered by the strong lamellæ of the dura mater. The lesser vessels again are removed from the shock: its force is spent, because it has spread among many branches; and it has become a general impulse upon the brain, which the brain resists, because it is incompressible.

That the brain does receive such an impulse, in violent coughing and straining, is sufficiently evident from the rising of its surface on these occasions, when it is accidentally laid open by fracture, or the trepan.*

Although the obstruction of the jugular veins were to cause no regurgitation of the blood; although the sinuses were supposed to have an effect in preventing the distention of the veins, or return of the blood to the head; still one effect of the continued action of the arteries is, to increase the plethoric state of the brain, when there is a stagnation, or more or less remora, of the blood in the sinuses; and thence it is, that in every interruption to the free exit of the blood, the distention must ultimately fall upon the extreme vessels.†

We ought not to confound the idea of incompressibility of the brain with that of a solid substance, which would allow no motion in the vessels within the cranium, and would require us to invent some specious means to account for the circulation of the blood in the brain, different from that of the other viscera of the body. Were the brain thus incompressible, or rather solid, so as to prevent a free action of the vessels within the cranium, then, as the blood enters with an evident pulsation, it must necessarily have returned by the veins with a distinct pulsation; but this pulsation is lost here, as in the other vessels of the body, before it returns by the sinuses. When the blood

* The older physicians, observing the connection betwixt the motion of respiration and of the brain, conceived that the air was drawn through the nose and cribriform bone into the brain, so as to distend it. Upon this hypothesis followed many wonderful cases.

We have already mentioned the hypothesis which supposed compression and relaxation of the cerebrum and cerebellum alternately, by the action of the falx and tentorium.

† We shall say that these vessels cannot suffer distention, unless there be space given for their inordinate dilatation, by blood proportionally sent out from the cranium. But there is a degree of distention upon them, a tension which cannot be relieved, nor the contraction of the arteries allowed. The impulse from the heart and arteries is still continued, and is increasing the evil. Bleeding here relieves this action, and diminishes the danger; and by this means we can suit the activity of the vessels entering the brain, to the temporary remora in those which convey the blood out of the head.

is sent into the arteries of the brain, by the stroke of the heart, they dilate; and this dilatation the pliability of the brain allows, by throwing a comparative degree of pressure upon the veins. Again, when the arteries (during the dilatation of the heart) are in action, and contract, their blood enters the veins, so as to give to them a degree of dilatation equivalent to their former compression, and which now gives the freedom of contraction in return to the arteries; without any compression, therefore, of the brain into a lesser space, there is an activity allowed in the vessels.

This degree of motion, communicated through the brain, is very small, nor does it affect the function of the brain; as we see, when the scull is laid open, and the pulsations of the arteries are, as it were, accumulated, in their effect, to one point; for here the patient does not suffer, although the brain beats so as to be sensible to the eye. The accumulation of the blood in the brain may be obstructed, or it may be accelerated, until this velocity affects the function:* or the blood may be accumulated; but during this accumulation of the blood there must be a proportional space, freed by the absorption of the brain itself, or the partial accumulation of one part of the vascular system of the brain must necessarily be accompanied by a deficiency of the other.

* There is much sound reasoning and ingenuity wasted on the subject of the circulation of the brain: as the gentle murmuring of a stream, says Lower, lulls to repose, while the mind is disturbed, or the imagination awakened by the din of a cataract; so sleep is induced by the gentle flow of the blood in the brain, or flies when the circulation is accelerated. As the fatigue and rest of the body required a variation in the impetus of the blood towards it, the necessary consequence was a variation in the degree of velocity in the circulation and quantity of blood in the head, and this to Lower is the reason of the vicissitude of wakefulness and sleep. The simple fact of the effect of pressure upon the surface of the brain inducing an oppression of the senses has occasioned all their theories of sleep to turn upon this one idea of pressure on the brain.

CHAP. III.

OF THE VENTRICLES AND INTERNAL PARTS
OF THE BRAIN.

OF THE CAVITIES OF THE BRAIN IN GENERAL.

TH**ERE** are within the Brain many tubercles and irregular surfaces, of which it is infinitely more difficult to convey an idea by description than of the external parts. These surfaces, as the name implies, lie in contact without adhering; and form what we call, though not perhaps with strict propriety, the cavities of the brain. Not being separated, they are scarcely to be considered as cavities, although they be capable of distention by the infiltration of the fluid into them. The surface of the cavities or ventricles of the brain is naturally bedewed with a fluid or halitus, which flows from the general surface of the ventricle, and from the plexus choroides. This moisture preserves those surfaces from adhesion; during life and health it is not accumulated so as to form a fluid; but in many diseases, and after death, it is effused or collected into a fluid. The external convolutions of the brain we have seen to be cineritious on the surfaces: the internal surface of the brain may be considered also as forming convolutions; but they are chiefly medullary, and are more irregular, or rather have a greater variety of shape, than those of the outer surface.

In regard to the use of the ventricles of the brain, since the hypotheses of the older physicians have been tacitly rejected, no opinion has been offered, except this, that "they seem to be made of a necessary consequence, and towards the greater use and distinction of parts;" or, as we have already had occasion to mention, that the ventricles serve to increase the surface of the pia mater, and that whatever may be the purposes which are served by that membrane on the surface of the brain, we must suppose the same to be performed by it within the ventricles. But this is a conclusion which may not be altogether satisfactory to an inquisitive mind.

It is necessary to take into consideration the general peculiarities of the brain: we find that within the skull there is no

adipose substance, though it pervades every other part of the body. We at once see a reason for this. It is evident that as the fat is so incessantly undergoing changes (being alternately absorbed and deposited;) as at one time it is deposited in greater quantities and at another absorbed; as it is in perpetual variation according to the prevailing habits of the body, the proportion of exercise taken, or the state of the health; its continual changes would have the very worst consequence upon such a part as the brain; that if accumulated it would oppress the circulating vessels; if rapidly absorbed it would be followed by accumulation or surcharge of the vessels; for the skull does not allow of distention, nor is it possible that it can admit of depletion.

I conceive the ventricles to be a provision for allowing those changes to take place, which necessarily, from time to time, arise, or are occasioned by disease in the substance of the brain itself: they prevent an instantaneous bad effect. When fluids distend the ventricles, it sometimes occurs to us that the fluid, secreted and accumulated, must have compressed the substance of the brain, and caused its absorption; but I conceive that frequently the cause is reversed; the absorption of the mass of the brain being the disease or its consequence, and the fluid being poured out in the ventricles to supply this deficiency: I also conceive that the collected fluid being in the central parts, is a particular provision by which the whole mass of the brain is kept uniformly distended; whereas, if the surface had been equally, or more disposed to such secretion of fluid, the internal parts would have fallen flaccid, and been compressed rather than supported.

There cannot be a more erroneous notion than that in Hydrocephalus the compression produced by the secreted fluid occasions the wasting of the brain. In that disease the substance of the brain is not firm and compressed, so as to prevent the veins from being completely filled; but, even in a very early stage, the mass of the brain is soft and fluid; the veins peculiarly distended or enlarged; and from the first or inflammatory stage of the acute hydrocephalus, or the permanent state of the chronic, the disease is not a dropsy of the ventricles, but a universal affection of the brain. The effect of the disease is, that there is a change in the relative powers which incessantly secrete and absorb the brain itself, as every other part of the body is secreted and absorbed. And in consequence of this there is a diminution of the solids of the brain, and an accumulation of the fluids to supply their loss.

It is not to be supposed that the ancients, so fertile in their hypotheses, and so easy in their proofs, could neglect the

evident importance of the ventricles of the brain. We accordingly find that the spirits were manufactured in these cavities; that they were the “*spirituum animalium officina*,” whence the spirits were conveyed over all the nervous system.* They were again degraded from this higher office, and became the mere receptacles of the excrementitious matter of the brain (*meras cloacas esse asseruerint*†); and Willis seems inclined still further to degrade the importance of the ventricles, by considering them merely as of secondary importance; or rather as resulting solely from the accidental conformation of the brain.‡ Again we find it a prevalent opinion that the ventricles contained air; that the air supported the soft medullary substance of the brain; and that it gave motion to the whole mass, so as to circulate the spirits in the substance of the brain.§

OF THE CORPUS CALLOSUM AND CENTRUM OVALE OF
VIEUSSENS.

THE CORPUS CALLOSUM is a medullary body which is a centre of communication; or it is the great commissure|| passing betwixt the hemispheres of the cerebrum:¶ it is seen without incision by merely separating those hemispheres with the fingers. It is a white body, firmer than the rest of the medullary substance. It is but slightly convex upon its upper part, but turns convex downwards upon the fore and back part. As the corpus callosum is the continuation of the internal medullary

* Lately by chemical aids, (which make the cineritious substance black, or dark brown, while the medullary matter remains white, or takes a slight greenish tinge,) the origins of many of the nerves have been traced into the substance of the brain, even to the surface of the ventricles, which has given occasion to the revival of similar ideas of the use of the ventricles.

† Willis Cereb. Anat. p. 32.

‡ “*Porro si quis cerebelli fabricam exacto considerat, et serio perpendit, quod hi ventriculi non ex primaria naturæ intentione efformentur, at secundario tantum et accidentaliter de cerebri complicatione resultent,*” &c.

§ Malpighi.

|| Commissure is a term applied to those tracts generally of medullary matter, which passing through the brain are supposed to be a medium of communication.

¶ Willis conceiving the spirits to lodge and circulate in the superficial convolutions of the brain, (upon the conformation of which depended the capacity or ability,) gives to the corpus callosum the property of collecting and concentrating the spirits, “*quasi in publico emporio commorantur;*” and here they were depurated by repeated circulation—But the language in which all this is delivered better veils the absurdities of the doctrine: “*spiritus recens nati undequaque ab extrema hujus corporis ora versus anteriorem istius corporis callosi partem, ubi crassimum existit perpetim blande scotent, ibidemque, si opus fuerit, aut imaginationis actui impenduntur, aut medullæ oblongatæ crura subeuntes, appendicem nervosam actuant et inspirant.*” What remains superfluous of the spirits returns backwards and circulates through the fornix, and is still farther subtilized, “*hoc motu subtiliores quoddam phantasiæ actus peragunt.*”

substance of the brain, it is superfluous to say that it is continued down, anteriorly, into the medullary matter betwixt the corpora striata, terminating in its pedunculi; or, backwards, that it is continued with the fornix and cornua ammonis and the surface of the posterior prolongation of the lateral ventricle.

We see upon the surface of the corpus callosum two medullary lines considerably raised, running parallel to each other* in the length of the body. Betwixt these salient lines there is of course a kind of rut, called sometimes the rapha, or suture, which may be considered as dividing this body into two equal parts, and which, in truth, forms the accurate division of the two sides of the whole brain.†

Other lines, less elevated from the surface, are to be observed running across these, as if passing from one hemisphere to the other. If the corpus callosum be cut horizontally, and the section be continued into the substance of the hemispheres, we still can perceive those transverse lines, and observe them to be lost in the medullary matter of the hemispheres.‡

THE CENTRUM OVALE is merely the appearance which the white and internal part of the cerebrum takes when the brain is cut horizontally on the level of the corpus callosum; for then the corpus callosum is the centre of the great medullary mass of the cerebrum, and the external cineritious matter being on the edges only forms it into an irregular oval.

THE SEPTUM LUCIDUM.

THE two lateral ventricles lying under the corpus callosum and medullary centre are divided by a partition, which descends from the lower surface of the corpus callosum, and rests upon the fornix. This septum of the ventricles is transparent, and consists of two laminæ, and these consist of medullary and cineritious matter.§ Betwixt these is the cavity of the sep-

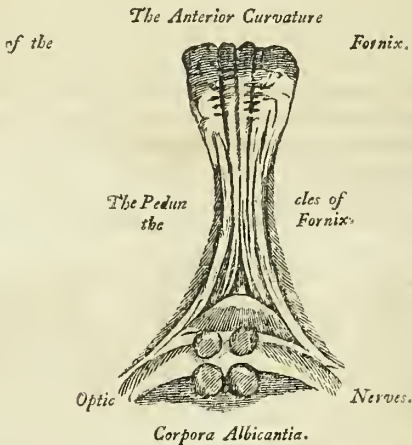
* They are not strictly parallel in all their length; we find them often separated both upon the fore and back part; but generally more separated upon the back part, and even sometimes they are curved.

† In which conceit Duverney calls this "clef du cerveau," from its being the centre of communication. Tom. i. p. 39.

‡ The necessity of explaining paralysis and convulsive motions of that side of the body opposite to the side of the brain injured, has made anatomists attend to those transverse lines, in the hopes of finding such a decussation of these lines as would account for it. Sabbatier says, they have brought themselves to believe that there was a decussation, but after careful investigation he could find no such thing. See Winslow. Ludwig (de Cinerica Cerebri, sub. p. 5.) observed striæ of cineritious substance in the corpus callosum. See also Gunz. and Haller.

§ Vicq d'Azyr.

tum lucidum.* The size and shape of this cavity differ in a variety of subjects. It is of a triangular shape, and from eighteen to twenty lines in length.† It has a fluid exhaling into it like the ventricles, and is by some counted as a fifth ventricle: according to Santorini it opens in the base of the brain, opposite to the union of the optic nerves. Vieussens describes it communicating with the third ventricle.‡ Winslow also has seen it reaching a great way backwards, and conceives it to open into the third ventricle. Soemmerring describes it as large in the middle, contracted backwards, and having no communication; but he asserts that it is shut in on every side.§ In the base of the brain we find a narrow longitudinal sulcus betwixt the pedunculi of the corpus callosum. In the bottom of this cavity there is a medullary lamina, which Vicq d'Azyr calls "*Cloison à la cavité du septum lucidum.*" And the sulcus he calls "*Fosse de la base du SEPTUM LUCIDUM.*" By a careful section of this medullary substance we lay open the cavity of the septum lucidum.



LATERAL VENTRICLES.

UNDER the corpus callosum and medullary centre, are the lateral ventricles. They are distinguished into right and left.

* It was discovered by Silvius. See also Santorini.

† Sabbatier.

‡ "In qua pellucidem non raro reperimus aquamque haud dubie in tertium illabitum ventriculum." Vieussens de Cerebro, p. 59.

§ De Corporis Humani Fabrica, tom. iv. p. 55.

They are of a very irregular shape, stretching into three prolongations or cornua, whence they have the name of tricornes. They are the great ventricles of the brain; the third and fourth being comparatively very small. What may be considered as the bodies of these ventricles are formed betwixt the corpus callosum and medulla of the brain, and the convexity of the corpora striata and thalami nervorum opticorum. Following the cavity forwards, we find what is called its ANTERIOR HORN or sinus, formed betwixt the more acute convexity of the corpus striatum and the anterior part of the corpus callosum; into the posterior lobe of the cerebrum, resting upon the tentorium, there stretches backwards with some considerable curve, and, at the same time, with a slight inclination downwards, the POSTERIOR HORN.

Again, the INFERIOR OR DESCENDING HORN is like the continued cavity of the ventricle; it takes a curve backwards and outwards, and then turning forwards it descends into the middle lobe of the brain.

The lateral ventricles do not terminate in the others by any of those prolongations; but they communicate, upon a very high level, with the third ventricle and with each other, by a wide opening, formed under the fore part of the arch of the fornix. This communication we easily find by following the choroid plexus forward and under the fornix: it is a space betwixt the most anterior part of the convexity of the optic thalami and the anterior crura of the fornix.

OF THE PARTS SEEN IN THE LATERAL VENTRICLES.

THE FORNIX is a medullary body, flat, and of a triangular shape, which divides the two lateral and the third ventricles: its lower surface is towards the third ventricle: its lateral margins are in the lateral ventricle. On its upper surface it supports the septum lucidum, or partition of the two lateral ventricles, and under its most anterior part is the communication betwixt the lateral ventricles and the third ventricle.* One of the angles is forward, and the other two towards the back part: it rests chiefly upon the thalami nervorum opticorum, but it is separated from them by a vascular membrane, which is continued from the external pia mater, and which stretches into the brain betwixt the posterior part of the corpus callosum and tubercula quadrigemina, and which membrane connects the plexus of the lateral ventricle. The fornix leaves betwixt it and

* Of this communication see farther in the Anatomy of the Brain illustrated by Engravings.

the concave face of the most anterior part of the corpora striata, a triangular space, which is in part occupied by the septum lucidum.

The extremities of this body are called crura. The posterior crura coalescing with the corpus callosum, (which is continued downwards posteriorly,) are prolonged into the hippocampi, and the anterior crura forming the anterior angle being close together, bend downwards behind the anterior commissure, and are connected with it: they then bend round the thalami, and may be traced into the crura cerebri; or, according to others, they form the corpora albicantia.* Those pillars or crura of the fornix are fibrous in some slight degree like a nerve. This is to be observed by cutting them either across or in their length.†

Upon the lower surface of the fornix there are lines like those of the corpus callosum, and which are erroneously conceived by many to be the impression of the vessels of the velum. It is this lower surface of the fornix which is called LYRA, CORPUS PSALLOIDES, it being compared to a stringed instrument.‡

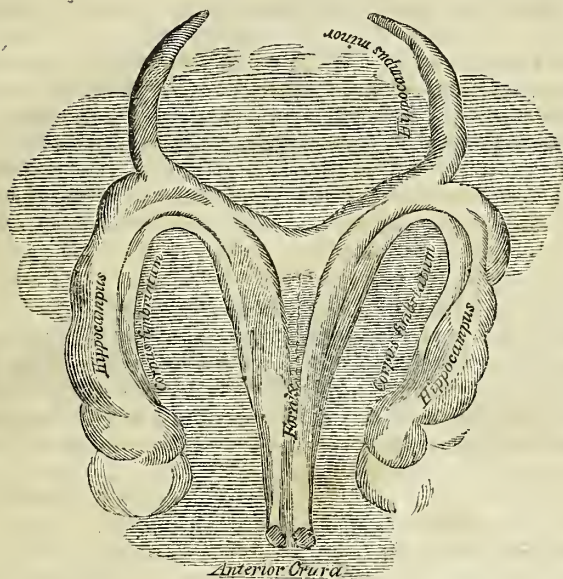
* Two white bodies seen on the base of the brain behind the infundibulum.

† Vicq d'Azyr, Acad. Scien. 1781, p. 517.

‡ The prevalent idea amongst the older authors regarding the use of the fornix was, that it acted like a ligament binding together the internal parts of the brain; or that it supported the incumbent weight of the upper parts of the brain from pressing upon the lower. "Verum alter atque iste insignior fornix usus esse videtur quem modo invenimus; nempe ut spiritus animales per ejus ductum ab altera cerebri extremitate ad alteram immediate transeant atque ita quasi per pellicani rostrum in sui ipsius ventrem intortum circulentur." Willis.

OF THE HIPPOCAMPI, OR CORNUA AMMONIS, AND OF THE
TENIA HIPPOCAMPI.

*Plan of the Connections of the Fornix with the
Hippocampus, &c.*



THOSE parts are to be seen continued from the posterior crura of the fornix. We have observed, that upon the back part, the fornix adheres to, or is continuous with, the corpus callosum. We shall find also that its posterior crus on each side divides into two laminae of medullary matter: the one of these is continued into the cornu ammonis, and the other (being the anterior of these portions) forms the tenia hippocampi.

The hippocampus is narrow at its commencement in the posterior crus of the fornix; * but it is enlarged as it descends,

* In speaking of the origin of the hippocampus as from the fornix, I mean simply that the student having gained the knowledge of one part of the brain may trace the others from their relation to it, and that, understanding the situation and relation of the fornix, he traces its crura until he finds them terminating in the hippocampus. We might fully as well say that the hippocampi are formed from the posterior part of the corpus callosum, for they are the same medullary matter continued.

following the course of the inferior prolongation of the lateral ventricle towards the base of the brain. It is, indeed, merely a relief or particular convexity of the floor of this lower horn of the ventricle, like a pad. The inferior extremities of the hippocampi on each side turn inwards, pointing to the crura cerebri, and taking thus a curve like a ram's horn.* In its whole extent the hippocampus consists of an internal cineritious substance, and a superficial layer of white medullary matter.†

The **TENIA HIPPOCAMPI**, or **CORPUS FIMBRIATUM**, is the prolonged margin of the fornix: it is merely the thin edge of the hippocampus, which follows in the whole of its circuit, and terminates in an acute point near its bulbous extremity.

The **LESSER HIPPOCAMPUS**, or **COLLICULUS**, is a relief or convexity in the floor of the posterior horn of the ventricles, which may be traced backwards from the crura of the fornix. It has the same relation to the fornix which the greater hippocampus has, and lies in the posterior horn or prolongation of the ventricle into the posterior lobe of the brain, in the same way in which the great hippocampus lies in the inferior horn or prolongation of the ventricle into the middle lobe of the brain.

The velum and plexus require to be taken away before we can fully understand the situation of the third ventricle, or of those tubercles which are but partially seen in the lateral ventricles.

The **VELUM** lies in the centre of the brain, and extends from the surface of the brain inwards betwixt the posterior lobes of the cerebrum and the cerebellum, then betwixt the corpus callosum and nates and testes, and then under the fornix. It forms thus a great communication betwixt the external and internal membranes of the brain. As it lies under the fornix, that medullary lamina adheres to it, while the velum again adheres to the thalami nervorum opticorum. Its margin seems to be terminated laterally by the choroid plexus (when we view it after raising the fornix;) but it is not strictly so, for the choroid plexus is continued with the membrane of the ventricles, and has no where a termination. For the vascularity of this membrane, turn to what has already been said in speaking of the internal veins of the brain.

* Betwixt the extreme point of the hippocampi and the crura cerebri (when the base of the brain is turned up) we can insinuate the probe into the inferior horn of the lateral ventricle without piercing the substance of the brain, but merely tearing the pia mater.

† “Vers la partie inferieure et posterieure du corps calleux, on trouve, de chaque côté, un petit bourrelet de substance grise qui se prolonge dans l'épaisseur de l'hippocampe dont il fait partie: bourrelet est recouvert dans son principe par une lame de substance blanche.” Vicq d'Azyr, loc. cit.

Seeing how the plexus choroides are formed and connected, they cannot be strictly said to have either beginning or termination; they are the connected folds and plicæ of the internal membrane of the ventricles loaded with vessels; but to describe them intelligibly we must, notwithstanding, trace them in this manner. The PLEXUS of the LATERAL VENTRICLES rise from the bottom of the inferior horns of these ventricles betwixt the pedunculi or crura cerebri and the termination of the hippocampi; they lie large and fleshy-like in that lower horn. As they rise into the superior level, they are at their greatest size (there they have often a diseased appearance, being hard, and as if schirrous or full of little vesicles or hydatids;) they then pass forwards and inwards, diminishing in thickness until they coalesce under the fornix, and immediately behind the communication betwixt the ventricles. The PLEXUS OF THE THIRD ventricle, formed by the union of those of the lateral ventricles, turns back upon the lower surface of the velum, and is comparatively very small.

The CORPORA STRIATA are smooth, cineritious convexities in the fore part of the lateral ventricle. They are somewhat of the shape of a pear; they are obtuse forwards; they approach each other towards the fore part with a regular convexity, and they are narrow as they pass backwards, separating at the same time; their posterior extremity being as it were pushed out by the thalami nervorum opticorum. These last lie more under the back part of the fornix, and are more concealed when the lateral ventricle only is laid open. These bodies are called striata, from the intermixture of the medullary matter, which gives the appearance of striæ when they are cut. They descend down to the base, and give origin to the first pair, or olfactory nerves.* The striæ of medullary matter pass from above downwards, they therefore appear in the horizontal sections of this body like white points. A superficial horizontal section of the corpora striata shows those striæ connected with the medullary matter of the middle and posterior lobe. A deeper incision brings into view a mass of cineritious substance betwixt those striæ and the medullary matter of the middle lobe. Another incision shows the course of the striæ altered, and brings into view the connection betwixt the corpora striata of each side, by means of the anterior commissure.†

* Sommerring.

† "*Hæc pars commune sensorium est, quod sensibile omnium ictus a nervis cujusque organi dilatos accipit adeoque omnis sensationis perceptionem afficit; cujusmodi sensibile ictus, cum hinc ulterius in cerebrum trajiciuntur sensationi statim imaginatio succedit; atque insuper hæc corpora, uti sensuum omnium impetus, ita*

The *COMMISSURA ANTERIOR* is a cylindrical medullary cord, which unites the fore and lower part of the corpora striata, and which spreads its connections for a full inch and a half into the middle lobe of the brain upon each side. We see it stretched transversely immediately under the anterior crura of the fornix. It is in figure like a bow; its extremities stretching (with a convexity forward) into the middle portion of the brain towards the extremity of the fossa silvii, where it terminates in the medullary matter of the middle lobe of the brain.

The *THALAMI NERVORUM OPTICORUM* are hid by the posterior angles of the fornix, and the plexus choroides: we do not see them fully until we have lifted the fornix and the velum or membrane which stretches under the fornix. They are somewhat of an irregular oval shape; they are whiter than the corpora striata, their surface being chiefly of medullary matter. Internally they are cineritious; and the medullary and cineritious matter is blended in striæ like the anterior tubercles of the ventricles on the corpora striata.

The thalami nervorum opticorum, having their convex surface towards each other, unite under the fornix by what is called the *COMMISSURA MOLLIS*, in opposition to the *commissura magna*, which is the corpus callosum; the *commissura anterior*, which unites the fore part of the corpora striata; and the *commissura posterior*, which is yet to be described.

Thus the soft commissure of the brain, or the union of the optic thalami, is so soft that the slightest force will tear it, or in dissection, the parts being unequally supported, the thalami will be separated and this connection lost.* After such separation of the tubercles there remains very little appearance of their having been united. Sabbatier, after the most careful dissection, says expressly that he could never observe this union, and he conceives, that in the smoothness of the contiguous surfaces he has a proof of there never being such a union; but he goes on to say, "The fruits of my research were, that I constantly found a soft cord of a cineritious colour, and about a line or a line and a half in diameter passing betwixt them."

I have seen, when the ventricles were distended in hydrocephalus, and the communication betwixt the three ventricles enlarged to a square cavity of nearly an inch in diameter,†

motuum localium spontaneorum primos instinctus suscipiunt. Willis, Edit. 4. p. 43.

* Morgagni and Vicq d'Azyr say they have seen this commissure double: it may, however, have been a partial laceration of it.

† In quadrupeds the adhesion is more extensive.

that this union was drawn out to some length, but still was above half an inch in diameter. The *commissura mollis* is exceedingly soft, of a cineritious colour, and vessels are sometimes seen to cross upon its surface. It seems to be the continuation of the grey or cineritious substance which covers the internal surface of the optic thalami.*

Towards the fore part of the thalami we have to observe a peculiar eminence or convexity, viz. the *ANTERIOR TUBERCLES* of the optic thalami. In making a horizontal section of the thalami, we find that we cut across a medullary streak or cord which descends from this tubercle to the mamillary processes, or *corpora albicantia*, in the base of the brain.† Its course is deep in the substance of the brain, and somewhat oblique. The limits of the thalami externally are contiguous to the *corpus striatum*, but betwixt them there intervenes a white medullary tract, which is continuous with the medullary striæ, and which, as it marks the limits of the two great tubercles of the lateral ventricles, takes a course inwards towards the anterior pillars or *crura* of the fornix and middle of the anterior commissure. The surface of this tract, as seen in the lateral ventricle, is the *TENIA SEMICIRCULARIS GEMINUM*, which we shall presently more particularly describe.

To understand the further connections and importance of the optic thalami we must dissect the base of the brain. There we find that it is through the *corpora striata*, and the *thalami nervorum opticorum*, that the *crura cerebri* establish their extensive connection with the internal mass of the brain; particularly we find that the *crura* shoot up into the back and lower part of the thalami.

Here on the lower part also we may observe the *TRACTUS OPTICUS*, which we may trace backwards from the optic nerves. They surround the *crura cerebri* with a semicircular sweep, swelling out at the same time, and terminating in three considerable tuberosities: they are finally confounded with the lower part of the optic thalami;‡ at the same time there runs up a division of it into the nates.

The *TENIA SEMICIRCULARIS GEMINUM* is the tract of the

* Mais il n'y a point de continuité, proprement dite, entre la substance intime de ces couches et la commissure molle dont il s'agit. Vicq d'Azyr, *Planc. de Cerv.* p. 23.

† See Vicq d'Azyr, plate xii. *Mem. de l'Acad. Royale*, 1781, p. 528, and plate 2, fig. 5.

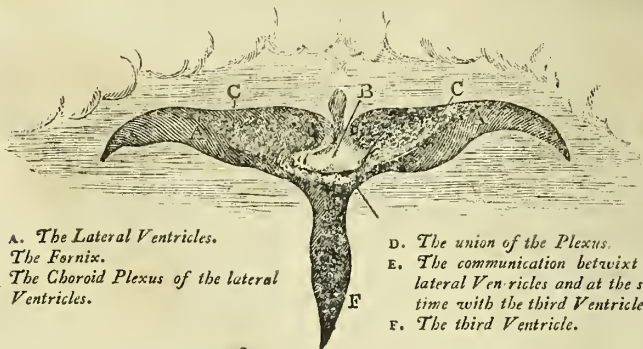
‡ Willis seeing the first and second pair of nerves so closely connected with these tubercles, and supposing, as we have mentioned in a former note, that the *corpora striata* were the common sensorium, concludes, "hinc ratio patet, cur odores sine olfactus objecta ipsum adeo cerebrum feriunt, et immediate afficiunt; item cur inter visionem et imaginationem communicatio citissima habetur," P. 44.

medullary matter, which is betwixt the two great anterior tubercles of the lateral ventricle, the corpus striatum and thalamus nervi optici. Towards the fore part of this tract its surface is covered with a layer of a semi-transparent greyish matter, through which we see the veins which pass from the surface of the corpora striata to join the vena galeni.* Sabbatier makes the anterior extremity of this medullary body join the anterior pillar of the fornix: Haller makes it join the anterior commissure: and Vicq d'Azyr says they separate again, where they seem to unite forwards and lose themselves on the corpora striata. Their posterior extremities are lost in the hippocampi; they thus form a kind of longitudinal commissure which establishes a communication betwixt the fore and back part of the cerebrum.

OF THE THIRD VENTRICLE.

THE third ventricle does not at all answer to the conception we form of the ventricles from the lateral ones. It is a mere sulcus, lying betwixt the thalami nervorum opticorum, and betwixt the crura cerebri, which are continued down from these tubercles. It is a longitudinal slit, rima, or gutter-like cavity, which is made irregular, and is divided by the union of the optic thalami; and finally, it is canopied by the fornix and vascular velum which stretches over the thalami.†

Plan of the communication of the Lateral and third Ventricles, represented by a Perpendicular Section.



- A. A. *The Lateral Ventricles.*
 B. *The Fornix.*
 C. *The Choroid Plexus of the lateral Ventricles.*

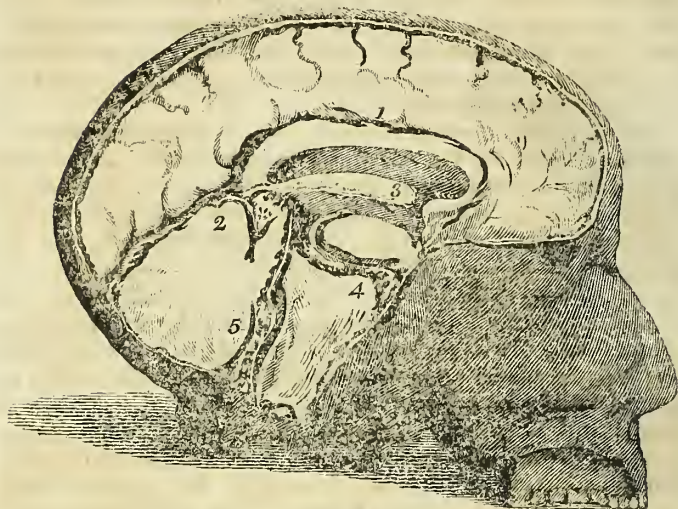
- D. *The union of the Plexus.*
 E. *The communication betwixt the lateral Ventricles and at the same time with the third Ventricle.*
 F. *The third Ventricle.*

* "Quelquefois il se detache du tania femicircularis entre le corps strié et la couche optique un filet blanc, que faisant un angle très aigu, soit en devant, soit en arriere, monte à une certaine hauteur sur le corps cannelé." Vicq d'Azyr, Mem. de l'Acad. Royale, 1781. p. 530.

† "Hanc caveam ventriculum tertium vulgo vocant, quæ et ipsa cum plena sint omnia nihil est nisi contiguorum thalamorum limes." Haller.

THE third ventricle opens forward and upwards into the two lateral ventricles, and under the common communication it opens into the infundibulum. Backwards it is continued by a canal which passes under the tubercula quadrigemina, or nates and testes, into the fourth ventricle. The bottom of the third ventricle is closed by a small stratum of cineritious matter, *cloison pulpeuse du troisieme ventricule*; this fills up the space betwixt the junction of the optic nerves and the anterior commissure. We see it when dissecting the base of the brain.—Lifting the optic nerves, we shall find it strengthened by the pia mater, and consisting of striæ which pass obliquely backwards and downwards, and some of which, while they adhere to the optic nerves, pass into them.

As we have found that the pia mater could be traced into the lateral ventricles, and as by tearing with the probe the connections of those membranes we could penetrate into the lateral ventricle without piercing the substance of the brain; so here we can penetrate into the third ventricle, which is deepest of all; and also into the fourth, without lacerating the substance of the brain. Thus, after raising the vascular membrane of the base, we can pass a probe under the corpus callosum backwards into the third ventricle, and by raising the cerebellum from the medulla oblongata, and separating the adhesions of the pia mater, we get access to the fourth ventricle. We conclude then, that the ventricles are not formed, as we should at first conceive, in the substance of the brain, but that they are formed by the replication and foldings of the convolutions of the brain.

Plan of the Inflections of the Pia Mater.*See foot Note,*

OF THE INFUNDIBULUM.

As I have explained in my tables of the brain, there is much confusion regarding the terms vulva and anus. Vulva is the space by which the three ventricles communicate, as seen when the fornix is lifted, viz. betwixt the thalami nervorum optico-rum and before the commissura mollis. The anus is behind this commissure, and near the nates and testes; both these are mentioned as communications betwixt the ventricles: but we know that the union of the plexus choroides, of the two lateral ventricles, and of the termination of the velum under the anterior part of the fornix, leaves the vulva free. But the velum spreading over the thalami, and under the posterior part of the fornix, closes up the anus; and it appears as a communication similar to the other only when the velum is torn up.

EXPLANATION OF THE PLATE.

1. The pia mater descending betwixt the hemispheres to the corpus callosum.
2. Betwixt the posterior lobe of the cerebrum and the cerebellum.
3. Under the fornix in form of the velum.
4. Into the inferior horn of the lateral ventricle.
5. Into the bottom of the fourth ventricle.

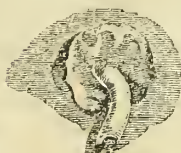
If we pass a probe gently downwards and forwards from the vulva or foramen commune anterius, or communication betwixt the ventricles, we pass it into the infundibulum. The INFUNDIBULUM is a funnel of a soft cineritious matter, which leads from the bottom and fore part of the third ventricle towards the glandula pituitaria, which is seated in the sella turcica of the sphenoid bone.

The infundibulum is formed of cineritious matter, which is continued from the bottom of the third ventricle, and which adheres to the back part of the optic nerves; or, according to Warthon, of an external membrane with cineritious matter internally. Its cavity becomes contracted before it reaches the glandula pituitaria. Whether it be really capable of conveying the fluids of the ventricles, or whether it be actually pervious, is likely to remain a disputed point. Tarin, and M. Adolphus Murray, and Haller, believe with the older writers that it is pervious. Soemmerring and Vicq d'Azyr have in their experiments found it shut.* But to the opinion that the infundibulum conveyed the superfluous moisture from the ventricles,† it did not seem necessary to Vieussens that we should find it to have a cavity in all its length. He conceived that where the apparent cavity terminated, less visible pores were continued towards the gland.

* "Sed non ad apicem usque pervium." Soemmerring.

† "Structura, situque infundibuli spectatis, connexionis, et societatis, quam cum cerebro, et glandula pituitaria habet, rationibus æquo judicio perpensis, unicum illius usum esse, ut aquosum, seu lymphaticum quemdam cerebro depluentem humorem, majoris, ad instar vasis lymphatici excipiat et pituitariam versus glandulam sensim transmittat, non autumare non possumus: etenim cum intertextarum plexibus choroidæis glandularum usus sit, ut sanguinis calvariam subeuntis, spiritusque animalis materiam suppeditantis, aquosiorum partem, desinentibus in ipsas ab arteriis depositum excipiant, que deinceps per insensiles rarissimæ, qua obducuntur, membranæ poros, sensum transfuit, et partim per vulvam partimve per anum, in tertium cerebri ventriculum delabitur; nullus esse videtur ambigendi locus, quin aquosus omnis humore glandulis, quæ plexuum choroidæorum vasis, interferuntur, sensim affluens, ad infundibulum deferatur." Vieussens, p. 50.— Such was the opinion regarding the œconomy of the brain, and now we have no theory, good or bad, nor any explanation of this connection of the gland with the ventricles of the brain to offer.

INFUNDIBULUM AND PITUITARY GLAND.

*Gland and Infundibulum
taken out.**Pituitary Gland Seated
in the Sella Turcica.*

What is called the PITUITARY GLAND is a reddish body of a glandular-like structure,* which is seated in the sella turcica of the sphenoid bone. It is plain upon its upper surface, or rather perhaps a little hollowed, of a globular shape below, and having a division into two lobes. The infundibulum terminates in it, piercing the dura mater, a thin lamina of which spreads over the gland. The gland, as is seen in the above plate, lies surrounded with the circular sinus, and has the cavernous sinus upon the sides; into these last, vessels have been seen to pass from the gland,† which, as Soemmerring observes, were probably veins. A distinction of substance has been observed in this gland, and it is by some considered as a part of the brain, or being like the cineritious substance, it has been supposed that it gave nerves to the fifth or sixth pair.

It was conceivèd that the body receiving the superfluous moisture of the brain, conveyed it into the nose; or into the neighbouring sinuses.‡ To countenance this opinion, there was no want of cases proving the accumulation of the fluids of the ventricles, in consequence of the schirrus of this gland,§ while in truth dissection has shown no connection betwixt the diseases of the ventricles and pituitary gland. M. Littre gave

* It perhaps has only the form of a gland. Haller says "non acinofa quidam, neque nullius alterius glandulæ similes, quæ potius cerebri quedam sit appendix." See also Bordeu, *recherch.—Anatomiq. sur les Glands.*

† Adolph. Murray de infundib.

‡ Lower Traçt. De Corde.

§ Schneider (de catarch.) first opposed this theory; showed that there was no communication betwixt the brain and the nose, and maintained that no fluid, not even the blood which flowed from the nose, had any connection with the brain: he was supported by other able anatomists. The old opinion was revived by M. Bouillet, *Eléments de Médecine pratique.*

both a vascular structure and muscular fibres to this body, and conceived that its operations brought down the water and air from the ventricles of the brain.*

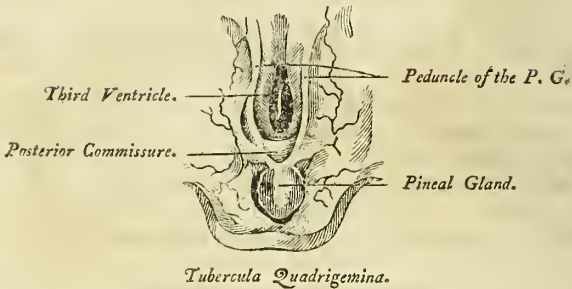
THE TUBERCULA QUADRIGEMINA.

THE tubercula quadrigemina, or nates and testes, are seen when we continue to lift back the posterior part of the fornix and corpus callosum, and when we have lifted back the velum with the vena galeni. We find, in doing this, that the velum is connected with the pineal gland, which is seated upon these tubercles. The tubercula quadrigemina are not in the cavities or ventricles of the brain, but are seen upon lifting and turning forward the posterior lobes of the cerebrum from the cerebellum.

These four tubercles are behind the third ventricle, and above the fourth. As they are immediately in the centre of the brain, they form a kind of commissure, and they both communicate with the tubercles, from which the tractus opticus emerge. The uppermost two are the NATES, the lower are the TESTES; the former are less white than the latter. A little under the inferior tubercle, we find sometimes a small tract of medullary matter, which extends to the thalami nervorum opticorum, and the crura cerebri. And from the lower part of the testes there projects backwards, connecting itself with the crura cerebelli, a thin medullary lamina, which is the VALVULA VIFUSSENI, PROCESSUS a CEREBELLO AD TESTES, or VELUM INTERJECTUM. Behind the posterior tubercle, or from this medullary lamina itself, the fourth pair of nerves take their origin. Sometimes those four tubercles are of the same size; sometimes the posterior, sometimes the anterior tubercles, are the larger: a perpendicular section of them shows a mutual communication of striæ of medullary and cineritious matter, but those are faintly seen only.

* See Littre, Mem. de l'Acad. des Sciences, 1707.

THE PINEAL GLAND.



THE pineal gland is seated above the tubercula quadrigemina, and behind the thalami nervorum opticorum; it is fixed, says Winslow, like a button. It consists of cineritious matter covered with the pia mater; its base is surrounded with medullary matter; it adheres firmly to the velum, and is apt to be displaced or torn from its pedunculi in lifting that membrane. It is a small soft greyish body, irregularly round, or of the figure of a pine-apple; or, of all things, most like the heart of a frog.* Its pedunculi, or footstalks, pass out from a transverse medullary base, which unites it to the posterior commissure. Those pedunculi pass on each side to the thalami nervorum opticorum (leaving a passage under and betwixt them to the fourth ventricle.) Their extremities pass forward upon the internal surface of the thalami nervorum opticorum, and are united to the anterior crura of the fornix.

Vicq d'Azyr remarks, that although the ideas of Galen and Descartes†, and a crowd of others are remembered only with ridicule, there are still some peculiarities in the situations and connection of this body, which marks its importance. It is composed of cineritious substance; it is in fact a prolongation of the substance of the brain, and by its pedunculi, which are like two nerves, it is connected with the thalami nervorum opticorum, with the fornix, and consequently with the corpus

* Ruysch considered the substance of this gland as different from that of the cerebrum or cerebellum, and different, also, from all other glands.

† Alluding to their opinion of this being the seat of the soul; Willis imposed upon this part a lower office, "Ejusque munus non aliud omnino esse quam aliarum glandularum quæ juxta vasorum sanguiferorum concursus disponuntur; nempe ut humores serofos, a sanguine arterioso depositos, excipiat et, in se retineat; donec aut venæ depletiores factæ eisdem resorbeant, aut lymphæ ductus (si qui adfuerint) eos extra convehant." Willis, p. 46.

callosum, the hippocampus and corpora albicantia, which are themselves the centre of union to several medullary cords; therefore he concludes that the pineal gland must be an important organ.*

The pineal gland has often in it little peculiar grains and calculi.† It has a great variety of form and size; I have found it surrounded with pus in an idiot boy, who was accustomed to wander about the Leith glass-houses. He died with symptoms of hydrocephalus, and in his ventricles, accordingly, there was found much fluid. Malacarne gives a case of its having degenerated into hydatids, like a cluster of grapes. It has not been found upon dissection in some cases.

POSTERIOR COMMISSURE.

The base of the pineal gland is connected with the posterior commissure of the brain. This commissure is seen like a cord, or like the anterior commissure, towards the back part of the third ventricle, before the tubercula quadrigemina, and above the iter ad quartum ventriculum. Betwixt this commissure and the base of the pineal gland, we have to observe two or three medullary filaments, not passing from the gland, but lying parallel to the commissure. But this part of the brain, which appears like a cord, does not deserve the name of commissure; it does not pass on each side into the substance of the brain as the anterior one does; it is lost in the neighbouring border of medullary matter, and is merely this matter reflected, so as to have a rounded edge.

OF THE FOURTH VENTRICLE.

THE fourth ventricle descends perpendicularly before the cerebellum; it is inclosed above by the valvula cerebri, below by the medulla spinæ, and on the right and left by the crura cerebelli.

* Mem. de l'Acad. Royal, An. 1731, p. 533. See Observ. par M. Mechel sur la gland pineale, sur la cloison transparente, et sur l'origine du nerf de la septieme paire. L'Acad. Berlin, 1765.

† “La parte anteriore della base n'è ordinari amente midollare, e qui appunto l'ho moltissime volte veduta gessata, offosa, tartarosa e friabile, vizi, che ho trovati anche molte volte, nei picciuoli.” Malacarne, part ii. p. 81. *Acerculus*; Meckel, Mem. de l'Acad. des Sciences a Berlin, 1755, fig. 1. b. b. Vicq d'Azyr, tab. xxvii. Super medullosum conarii vinculum vel in ipso vinculo, vel in ipso denique acervulo, plerumque vero ante acervulum iam in fetibus immaturis peculiare quidam lapilli, mox maiorum acervulum, mox vero duo vel tres minores acervulos constituentes, helui, semiperlucidi, iunioribus semper pallidiores, annosioribus fusciores, infantibus ob coloris languorem et perluciditatem difficiles cognitu ficcati albidiores et opaciores inveniuntur.” Soemmerring, p. 63.

When we pass our probe obliquely backwards and downwards under the posterior commissure, it passes into the *ITER AD QUARTUM VENTRICULUM*, or *AQUEDUCT* of *SILVIUS*. This passage to the fourth ventricle, goes before the *tubercula quadrigemina*. The *VALVULA VIEUSSENI*, it was supposed, prevented the falling down of the moisture of the other cavities into the fourth ventricle :* it is more properly called the *PROCESSUS CEREBELLI AD TESTES*, being a medullary lamina spread over the ventricle and betwixt the *crura cerebelli*, as they rise from the *ARBOR VITÆ*, or the internal medullary part of the cerebellum.

From the aqueduct there is continued down upon the fore part of the fourth ventricle a kind of fissure, which Vesalius, conceiving it to have some resemblance to a writing quill, called *CALAMUS SCRIPTORIUS*. The same fissure or furrow is continued down some way upon the spinal marrow.

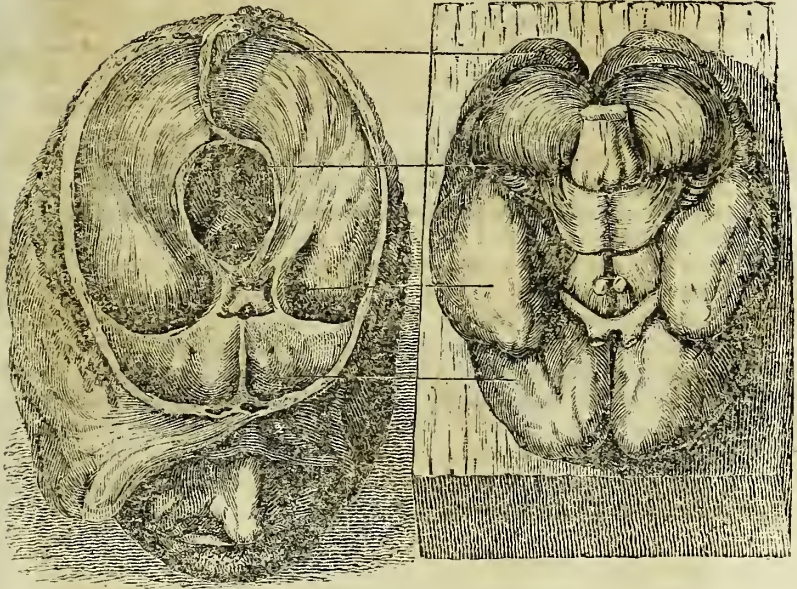
There pass up obliquely outwards, on each side of the *calamus scriptorius*, medullary lines, three or four in number, but sometimes seven are observed.† One of these fibres ascends to the *valvula Vieussenii*; some are the origins of the auditory nerve, and one or two *striæ* go to form part of the eighth.

In the fourth ventricle, as in the others, are some convolutions of the *plexus choroides*; these are on each side at the termination of the *vermis*; they are continued out upon the base of the brain, and are seen exposed betwixt the seventh and eighth pair of nerves.

* *Alveus Silvii*.

† Haller, *Physiol.* tom. iv. p. 78.

OF THE BASE OF THE BRAIN AND ORIGIN OF THE NERVES.

Relation of the Brain and Skull-cap.

We have anticipated much that might have fallen to be treated of in this division of our subject ; but my intention here is to give a connected view of the parts, as seen when we have raised the brain from the skull, and when, having the base presented to us, we are about to enumerate the origins of the nerves.

The first appearance which strikes us is the great proportion of the medullary matter in the base of the brain ; the whole surface of the brain, while seen from above, was cineritious, but now the central medullary part of the brain is seen emerging from the envelopement of the cineritious matter, and, gathering together from the several internal medullary processes of the brain, it concentrates the essential properties of the encephalon, and is fitted to give out the several nerves.— Those great medullary prolongations of the cerebrum and cerebellum, are called the crura.

The CRURA CEREBRI are composed of a white fibrous medullary matter, in which also there is a mixture of cineritious

substance. They are formed from the whole central medullary part of the cerebrum ; or more immediately from the inferior and lateral part of the corpora striata, and from the superior and internal part of the thalami nervorum opticorum ; and, from the conflux of medullary matter, from the anterior and posterior lobes of the cerebrum. From all these various parts the medullary matter, passing downwards and backwards, forms the crura.* The crus of either side of the brain, contracting their diameters, unite at an acute angle, and are united to the pons varolii, or nodus cerebri, formed by the crura cerebelli ; they pass on to form the medulla oblongata, and, as they unite with it, they raise it into the eminences, called Corpora Pyramidalia. In those processes of the cerebrum, the cineritious and medullary substances mingle with some degree of confusion ; so that when we make a section of the crura cerebri near to their union with the pons varolii, we observe a substance of a dark-brown colour, surrounded with white or medullary matter. In the angle of the union of these crura cerebri, behind the corpora albicantia, and before the protuberance of the pons varolii, we observe a matter less perfectly white than the surrounding medullary substance, which forms a floor to the third ventricle. This part is perforated with a great many holes, and is the *substance perforée* of Vicq d'Azyr, † and gives origin to the third pair of nerves along with the crura themselves.

CRURA CEREBELLI.

THE crura cerebelli are more exposed than those of the cerebrum ; the latter lying deeper, and being comparatively smaller. They are formed by the union of the internal medullary part of the cerebellum, or the arbor vitæ. They are altogether composed of medullary matter, except near the pons varolii, where we observe a mixture of coloured striæ.

PONS VAROLII.

THE PONS VAROLII, TUBER ANNULARE, OR NODUS CEREBRI is formed by the union of the crura cerebri and cerebelli ; those names are almost descriptive of its shape and relation to the other parts. Varolius, looking upon those parts inverted, com-

* I speak still of the relation of those to each other, according to their natural situation in the skull.

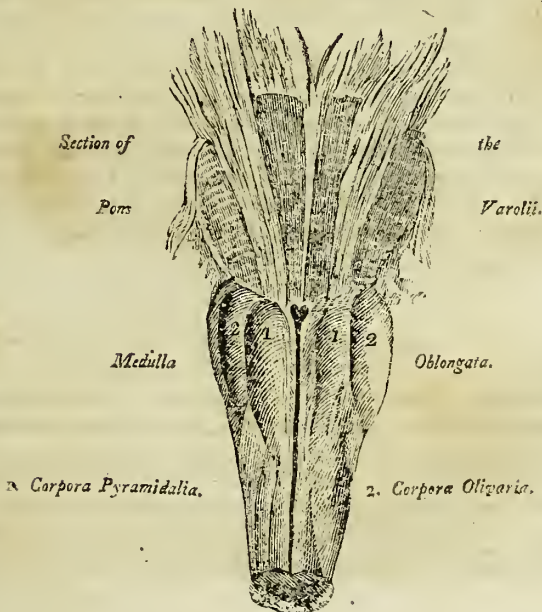
† Vicq d'Azyr makes three divisions of this *substance perforée*—1st, At the roots of the tubercles, from whence the first pair of nerves emerge betwixt the roots of those nerves, and near the origin of the optic nerves. 2. Those I mention betwixt the crura cerebri. 3d. On the outer contour of the optic thalami.

pares the crura cerebri to a river passing under a bridge, and thence named it Pons. The nodus cerebri, again, is a name well applied, since this medullary eminence has much the appearance of a knot cast upon the medullary processes of the cerebrum, and is in fact the central union of the elongated medullary matter of both cerebrum and cerebellum.

On the surface of this medullary protuberance there are many transverse fibres, which, uniting in a middle line, form a kind of rapha, which, upon a superficial section, shows a longitudinal medullary line. The fibres upon the surface of this body are uniform and parallel to each other in the most projecting part; but upon the sides, they disperse to give place to the fifth pair of nerves and crura cerebelli.

A deeper incision of the pons varolii, while it shows the intimate union of the crura cerebri, cerebelli, and pons varolii, also shows the white medullary tracts which extend from the crura cerebri through the pons varolii to the corpora pyramidalia; part of these pass through the LOCUS NIGER CRURUM CEREBRI, and can be traced to the corpora striata. We see also the transverse fibres of the medullary and cineritious substance, which makes a right angle with these longitudinal tracts.

MEDULLA OBLONGATA.



THE medulla oblongata is the prolongation of the substance of the crura cerebri and cerebelli, and the pons varolii; it is consequently the continuation of the encephalon, which, after giving off the nerves that pass through the foramina of the skull, enters the canal of the spine to supply the spinal nerves. The medulla oblongata is marked at its upper end by a deep sulcus dividing it from the pons varolii; but towards the spinal cavity it decreases in thickness, and there is no natural distinction or sulcus to mark the point where the medulla oblongata ends, and the medulla spinalis begins: nor perhaps is the medulla oblongata to be considered in any other light than as the beginning of the spinal marrow. When it passes the foramen magnum, it ceases to be called the medulla oblongata.

We have to observe four eminences upon the medulla oblongata, viz. two corpora pyramidalia, and two corpora olivaria. The CORPORA PYRAMIDALIA, so called from their shape, are those in the middle. There is formed betwixt them and the pons varolii (being three tubercles placed together) a little sulcus, which some have called the FORAMEN CÆCUM. Betwixt these eminences there is a longitudinal fissure, in the bottom of which there may be observed transverse little cords, which are like commissures connecting the two sides of the medulla oblongata.

The CORPORA OLIVARIA lie upon the sides of the corpora pyramidalia. They are in some degree, like them, limited by the sulcus which bounds the pons varolii, rounded above and bulging, but gradually subsiding, at their lower part, into the level of the medulla spinalis; yet they are internally different, for anatomists had observed a mixture of a yellow or cineritious coloured matter in the corpora olivaria, but Vicq d'Azyr has observed a regular oval medullary substance, or body surrounded with cineritious coloured substance, like a miniature representation of the cerebrum itself; he calls it CORPUS DENTATUM EMINENTIÆ OLIVARIS.

MEDULLA SPINALIS.

THE medulla spinalis, from its structure, its two substances, its membranes, and its use, as evident in the consequences of injury, must be considered as an elongation of the brain. Its name implies its situation contained within the tube of the spine. Though chiefly composed of medullary matter, it is not entirely so; for there is an irregular, central, cortical substance, through its whole extent, having something of a cruci-

al form in the section of this part.* There are continued down from the calamus scriptorius behind, and the rima, formed by the corpora pyramidalia, before, two fissures which divide the spinal marrow into lateral portions. On the back part, however, the fissure is very little distinguishable. Into the anterior one the little vessels penetrate to supply the cineritious matter with blood. The spinal marrow diminishes in thickness as it descends in the neck ; but below the giving off of the brachial plexus it again enlarges, then continues gradually to diminish.

The tube of the vertebræ is connected by a strong ligamentous sheath, which runs down the whole length within the tube. The dura mater, after lining the internal surface of the cranium, goes out by the great foramen, and forms a kind of funnel ; at the occipital foramen it is united firmly to the ligament. Under this, however, it forms a separate tube. The tunica arachnoides again adheres loosely, having a kind of secretion within it, while the pia mater closely embraces, and is intimately united to the medullary matter.

From betwixt the ninth nerve and vertebral artery to the second and third lumbar nerve, there is a membranous connection betwixt the lateral part of the spinal marrow and the dura mater of the spine. From the manner of its connection to the dura mater, by distinct slips irregular and pointed, it is called the Ligamentum Denticulatum, or Dentatum.

SCHEME AND GENERAL DESCRIPTION OF THE ORIGINS OF THE NERVES OF THE ENCEPHALON AND SPINE.

In enumerating the nerves which pass from the cranium, I shall keep to the old way of Willis, counting only nine nerves of the encephalon. I do not find that the subdivisions of the nerves in this classification, and the description of the several fasciculi, of which the pairs of nerves are composed, cause intricacy. It rather, I am from experience convinced, connects some circumstances with many of the pairs of nerves thus enumerated, to which the memory of the student can attach.—The common enumeration seems a natural one ; it serves well the purpose of dissection, and consequently will never be entirely exploded. The use of new classifications and arrangements, and names, whilst we must also retain the old, adds much to the intricacy of demonstration.

* The surface of the spinal marrow has also been observed to be of a darker colour, and in large animals distinctly cineritious. (Dr. Monro's Nervous System.)

From the olfactory nerve to that which passes out betwixt the cranium and first vertebra, there are nine nerves.*

1st pair—Olfactory nerves.	<p><i>Carunculae mamillares</i> Math. de Grad. <i>Processus ad nares.</i> Gonth d'Andernc. 8^{um} par, Spigel. 1st pair of Willis.</p>
2d pair—Optic nerves.	<p><i>Nervus visivus, seu visorius.</i>—Carpi. 1^m par antiquorum. 2d pair of Willis.</p>
3d pair—Motores oculorum.	<p>2^{um} par, Fallop. et Vesal. <i>Nerfs moteurs communs des yeux.</i>—Winslow. 3d pair of Willis.</p>
4th pair—Trochlearis.	<p><i>Minor propago</i> 3ⁱⁱ Paris, id est 5ⁱ recentiorum, Fallop. <i>Gracilior radix</i> 3ⁱⁱ Paris, id est 6ⁱ recentiorum. Vesal. <i>Nervus qui prope nates oritur.</i> Eustach. 9^{um} par Cortes: et Columb. 4th pair; or, pathetic nerves of Willis.</p>
5th pair—Trigemini.	<p><i>Nervus anonymus trigeminus multorum.</i> 3^{um} par Fallop. et Vesal. 5th pair of Willis. Trijumeaux of Winslow.</p>
6th pair—Abductores.	<p>4^{um} par Fallop. <i>Radix gracilior</i> 5ⁱ Paris, id est 7ⁱ recentiorum Vesal. <i>Par oculis prospiciens.</i> 8^{um} par Capp. Bauhini. 6th pair of Willis. <i>Nerfs oculo-musculaires, ou moteurs externes de Winslow.</i></p>

* In the following table, I am of course much indebted to the synonymic of Vicq d'Azyr.

7th pair	} Auditory nerves.	{	2 ^{um} par Alexand. Benedict.
			4 ^{um} par Carol. Stephan.
7th pair	} Nervus communicans faciei.	{	5 ^{um} par Vesal. et aliorum.
			6 ^{um} par V. Horne.
			Portia mollis, of the moderns.
			<i>Distinctus a molli nervus.</i> Fallop.
			<i>Portio ut præcedens, 5ⁱ Paris, id est 7ⁱ recentiorum.</i> Vesal.
			Portio dura, of the Moderns.
8th pair	} Glosso-pharyngeus.	{	Le petit sympathique, of Winslow.
			Facial nerve.
			<i>Qui ad musculus linguæ et faucium tendet.</i> Fallop.
			Le rameau lingual de la 8 ^e paire of Winslow.
			8th pair d'Andersch.
			Superior fasciculus of the 8th pair of Willis.
			<i>Glosso Pharyngeus.</i> Haller.
			<i>Nervus sextus Galeni et aliorum.</i>
			5 ^a conjugatio Carol. Stephan.
			7 ^{um} par Alex. Benedict.
8th pair	} Par vagum.	{	6 ^{um} par Casp. Bauhini.
			9 ^{um} par Bidloo et Andersch.
			8th pair of Willis.
			Le moyen sympathique of Winslow.
8th pair	} Spinal accessory nerve.	{	The spinal nerve.
9th pair—Lingual.	}	{	7 ^{um} par Fallop. Vesal. et aliorum.
			11 ^{um} par Bidloo.
			10 ^{um} par Andersch.
			<i>Par linguæ medium, vel nervus lingualis medius.</i> Haller. Saemmerring et aliorum.
			The hypoglossal, <i>sublingual</i> , or gustatory.
			The 9th pair of Willis.

10th pair—Suboccipital
nerve.

} 10th pair of Willis.
} 1st spinal, or cervical nerve, of
} Haller. I count this the first
} cervical nerve.

FIRST PAIR; OR, OLFACTORY NERVES.*

The olfactory nerve is soft and pulpy, and soon resolved by putrefaction; therefore, we should not be surprised that it was neglected by the Ancients†. It adheres firmly to the lower surface of the anterior lobe of the brain, but it does not take its origin here. It is of a triangular shape, as if moulded to the sulcus in which it lies; by being sometimes sunk into the sulcus more or less on one side than the other, it has the appearance of being larger on one side than the other. It takes its origin by three medullary tracts‡; 1st, From the Corpus striatum; 2d, From the medullary matter of the anterior lobe; 3d, From the fore and under part of the corpus callosum.§ When a section is made of it, we observe in it a cineritious portion.

Towards the fore part, this nerve expands into a bulbous oval lobe, which consists of a semi-transparent cineritious substance. This lies upon the cribriform plate, and from it are sent down the nerves which expand upon the membrane of the nose, and compose the organ of smelling.||

* In the present enumeration and description of the nerves, we attend chiefly to their relation to the brain. In the introduction to the next part of this volume, they will be found arranged and classed previous to the detail of their minute distribution.

† The olfactory nerve is in brutes a large prolongation of the substance of the brain, and is the proper mammillary processes. Their olfactory nerves have a cavity or ventricle in them, and it was natural for the Ancients to imagine that the pituita of the brain was from this strained through the cribriform plate into the nose. Vesalius proved the absurdity of this opinion; it was, however, revived by Dulaurens, who was perhaps more of a courtier than an anatomist. But Willis is not much better, when he describes the proper use of these nerves. He supposed the cribriform plate of the æthmoid bone to prevent bodies from passing up into the brain (“ne quid asperi aut molesti cum illis una ad cerebrum feratur;”) while the lymph in those nerves corrected the two pungent odours; “odorum species demulcere easque sensorio quadantenus præparare.”

‡ Or we say that the external root generally splits, having two fasciculi. See Prochaska, tab. 1.

§ Vicq d’Azyr, M. de l’Acad. Roy. 1781.—“Breviores fibræ medullaræ cum longioribus exterioribus connexæ nonnunquam cineream particulam excipiunt.” See *Sæmmerring*.

|| Duverney has shown us, that those nerves passing through the cribriform plate become firm nerves, like those in the other parts of the body. They are to be seen by tearing the membrane of the nose from the bone.

SECOND PAIR ; OR, OPTIC NERVES.*

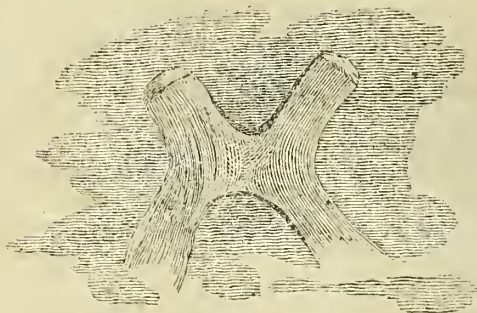
THE optic nerves arise from the posterior part of the optic thalami, and also (and perhaps more directly†) from the tubercula quadrigemina. When we trace the optic nerves backwards into the tractus opticus, we find them taking a circle round the crura cerebri, then enlarging, each forms a tubercle towards the back part of the thalamus opticus, and afterwards unites with the posterior tubercle of the thalamus opticus; at the same time a division stretches towards the testes, while betwixt the posterior tubercle of the thalamus opticus and the nates, there is an intermediate communication. When those tubercles are fairly exposed by separating the middle lobes of the brain, and dissecting away the tunica arachnoides and pia mater, they are seen smooth, and formed of medullary matter; which is uniformly continued from the one to the other, following their gentle convexities with an uninterrupted surface. Within those tubercles is a mixture of cineritious and medullary matter, and, especially, there is a distinct streak which passes from the tractus opticus to the nates.

Thus there is a communication betwixt the nates and testes, and the optic nerve; but we must still consider the nerve as arising in a peculiar manner from the thalamus opticus, while at the same time it receives additions from the crura cerebri, where the nerve adheres closely to the crura.

Tracing the optic nerves from their origin in the brain towards their exit from the skull, we find them approaching gradually and uniting just before the corpora albicantia and the infundibulum.

* The optic nerves were the first pair of Galen and many of the older anatomists, they being ignorant of the olfactory nerves.

† "Les nerfs optiques naissent en arriere des eminences nates et testes vers la partie posterieure de celles que l'on nomme les couches des nerfs optiques." *Sabbatier*.

Section of the Union of the Optic Nerve.

Since the days of Galen, it has been a disputed point, whether there is a union simply of the nerves, or a decussation. Fishes have the nerve arising from one side of the brain passing to the eye of the other side: they cross, but they do not unite. Birds have but one optic nerve arising from the brain, which splits and forms the right and left optic nerves. Vesalius dissected a young man at Padua, who had lost his eye a year before; at the same time he dissected a woman, whose eye had been lost a long while. In the latter he found the nerve of that side smaller, firmer, and of reddish colour, through all its extent. In the young man he observed no effect upon the nerve. He also gives a plate of an instance in which he found the optic nerves pass on to the eyes of the same side from which they take their origin, without adhering at all.

Valverda, a physician of Spain, who travelled into Italy, and studied the Works of Vesalius and Human Dissection, says that at Venice he had frequent opportunities of assuring himself that there was no decussation; for robbers were punished for the first offence by losing one of their eyes; and for the second by death. Riolinus, Rolefinkius, and Santorini, give observations of the nerve of the injured eye being small and shrivelled, and of their having traced them past their union to the same side of the brain with the eye to which they belonged. Vicq d'Azyr, who, of all authors I conceive to be the best authority upon such subjects, is decidedly of opinion that there is no decussation. Zin also agrees with the opinion of Galen, that there is an adhesion and intimate union of substance, but no crossing of the nerves. Soemmerring deems it sufficient to point out the authorities on both sides of

the question, while he has no decided opinion whether there be a perfect decussation or not.* Porterfield, while he allows the intimate union of the optic nerves, has several observations, proving that they have no intersection or decussation.

Sabbatier, encouraged by the authority of Morgagni, says, that he could trace the affection of the nerve of the injured eye no farther than to the union. He discredits the accounts of their having been traced to the same side of the brain, and believes the assertions to be the consequence of previous opinion and prejudice. There are certain observations of Valsalva, Cheselden, and Petit, which seem to prove, that where the brain is injured, it is the eye of the opposite side that is affected†. After their union the optic nerves are much contracted in diameter; still the optic nerve is the largest of the head, excepting the fifth pair. It is the firmest of all the nerves of the senses, but softer than the other nerves‡.

What remains to be said of the optic nerves, falls more naturally to be treated of when speaking of the organ of vision.

THIRD PAIR OF NERVES; MOTORES OCULORUM.

THE third pair of nerves arise from the internal margin of the crura cerebri, and the perforated medullary matter which is betwixt the crura. The delicate filaments of this nerve cannot be traced far into the substance of the brain, but still we may observe them spreading their filaments, and traversing the dark coloured spot which we have already mentioned to be visible in the crura cerebri. Some anatomists have said, that the third pair of the nerves had an origin also from the nates and testes. Ridley describes them as rising from the pons varolii§.

In relation to the arteries, those nerves are betwixt the posterior artery of the cerebrum, arising from the division of the basilar artery and the anterior artery of the cerebellum||. They diverge from each other, as they proceed forwards, and each penetrates under the anterior point of the tentorium by

* "Ergo, utrum omnes nervorum fibræ, an quædam tantum mutuo se fecerint, certe statui nequit."

† If Petit and others are proving that the optic nerves are affected in the side opposite to the injury of the brain, they are proving that they have no decussation; for if they had, it would counteract that effect, which, from the structure of the brain, they must have in common with the other nerves.

‡ Soemmerring.

§ They seem to come from the angle betwixt the crura cerebri and pons varolii, They are flat near their origin, but become round and firm.

|| "Cette disposition peut expliquer pourquoi on éprouve tant de pefanteur aux yeux aux approches du sommeil, dans l'ivresse & dans certains especes de fièvre." Sabbatier. This is a mechanical and a most improbable way of accounting for such an effect.

the side of the cavernous sinus, and passes through the foramen lacerum. In the general description it is sufficient to say, that they are distributed in common to all the muscles of the eye.

THE FOURTH PAIR OF NERVES.

THE fourth pair of nerves, pathetici, or trochleares, are the smallest nerves of the encephalon, being not much larger than a sewing thread. This nerve comes out from betwixt the cerebrum and cerebellum, passes by the side of the pons varolii, and after a long course pierces the dura mater behind the clynoïd process, runs along for some way in a canal or sheath, formed by the dura mater; it then passes through the cavernous sinus, continues its course onwards through the foramen lacerum to the orbit, and is finally appropriated to the superior oblique muscle of the eye.

The origin of the fourth pair, if we take implicitly the descriptions of authors, seems to have a much greater variety than any of the other nerves; so that it is common to say, the fourth pair of nerves arise about the region of the nates and testes*. The trochlearis arises sometimes by two filaments, but more commonly by one undivided root†. This root is seen to emerge from a point betwixt the medullary lamina of the cerebellum, or valvula Vieussenii, and the lower of the tubercula quadrigemina‡.

From the connections of the parts whence this nerve arises with the rest of the brain, it is presumed, that this fourth pair of nerves has a very immediate and universal connection with the internal parts of the brain; yet there is nothing in the final distribution of the nerve, which should incline us to believe that there should be any particular provision in its origins.

* "Pone corpora bigemina posteriora mox paullo superius, mox paullo inferius, mox magis exteriora, mox magis interiora versus radice simplici, duplici, triplici, quin et quadruplici oritur. Nonnunquam origo ejus in cerebri valvula, nonnunquam in ipso frenulo patet ut humore ventriculi quarti alluatur." *Soemmerring*, vol. iv. p. 209.

† Santorini says, they have three roots or little fasciculi. *Wrisberg* following *Vieussens*, says, the fourth pair arises from the valvula cerebri. *Vicq d'Azyr*. See *Haller* fas. vii. tab. 3. "Origo alius simplex est, alius duplex; quando simplex est, a processu a cerebello ad testes exterius prodit, quam est transversa stria, quæ eos processus conjungit." *Haller* Phys. vol. iv. p. 208.

‡ Et souvent ils se confondent avec un tractus medullaire placé transversalement au-dessus de la valvule du cerveau." *Vicq d'Azyr*. This nerve, says he, cannot be followed into the anterior part of the brain from its extreme delicacy, and because it is formed from the medullary substance itself, without the admixture of filaments to give it strength. He quotes those words of *Soemmerring*:—"Continua medulla oritur."

FIFTH PAIR OF NERVES ; TRIGEMINI.

THE fifth nerve of the brain arises from the fore and lowest part of the crura cerebelli, where they unite with the pons varolii. The origin of this nerve may be divided into two portions : an anterior is small, and somewhat elevated above the other. The posterior part of this origin takes its rise a little lower than the anterior part. These two origins of the nerve are connected by cellular membrane, and have betwixt them a little groove, in which not unfrequently an artery creeps. According to Santorini, the anterior of these divisions is formed by the transverse fibres of the pons varolii, and the posterior by the crura cerebelli. But this nerve appertains truly to the cerebellum ; and Vicq d'Azyr could never, except in one dissection, perceive that any of its fibres arose from the pons varolii*. The nerve of the right side has been observed sometimes larger than that of the left.

This fifth nerve, the largest of the skull, passing forwards and downwards, slips in betwixt the lamina of the dura mater, opposite to the point of the pars petrosus of the temporal bone. It is here firmly attached to the dura mater, and forms a flat irregular plexus. From this plexus there pass out three great branches :—1st, One to the socket of the eye and forehead, through the foramen lacerum ; 2d, One to the upper jaw and face, through the foramen rotundum ; and 3d, One to the lower jaw and tongue, passing through the foramen ovale.

SIXTH PAIR OF NERVES ; OR, ADDUCENTES†.

THE sixth nerve of the skull seems to arise from betwixt the pons varolii and medulla oblongata. In the origin of its fibres it has, however, much variety ; and authors differ very much in this point of the description‡. We may say, however, that the sixth pair of nerves arises from the corpora pyramidalia.—Sometimes the nerve rises in two branches, which do not unite until they are entering into the cavernous sinus‡. The sixth nerve is in size somewhat betwixt the third and fourth : it passes forward under the pons varolii, until near the lateral

* “ Oritur e nodo cerebri, prope cerebellum duabus partibus, &c.” Soemmering.

† Or, motores externi.

‡ Simple as the anatomy of the nerve is, Vieussens, Morgagni, Lietaud, Winslow, Sabbatier—all differ in their account of the origin of this nerve in some little circumstance ; and Vicq d' Azyr gives six varieties of it.

§ Sabbatier.

and lower part of the body of the sphenoid bone : it thence continues its route forwards and downwards by the side of the carotid artery, through the cavernous sinus : here it seems increased in size.—It gives off that small twig which anatomists account the beginning of the great sympathetic nerve.—The sixth nerve, after giving off this delicate thread, passes on through the foramen lacerum to the abductor muscle of the eye.

SEVENTH PAIR OF NERVES ; OR, AUDITORY.

THE seventh nerve arises from the posterior and lateral part of the pons varolii, at the point, where it is joined by the crura cerebelli.

But this seventh pair of Willis consists of two parts ; the facial nerve or portio dura, and the auditory or portio mollis ; the last is the larger and posterior portion.*

THE PORTIO DURA comes out from the fossa formed betwixt the pons varolii, corpora olivaria, and crura cerebelli ; † and upon a more careful examination we find it rising distinctly from the crus cerebelli.

The origin of the portio mollis, of the seventh pair, is to be traced from the fore part of the fourth ventricle. ‡ We observe passing obliquely upwards from the calamus scriptorius several medullary striæ ; those vary in number from two to seven, and are sometimes not to be discerned. § To these are added certain fibres arising from the pons varolii, and as these fibres proceed from their origin, they become still more distinctly formed into fasciculi. The whole of this portio mollis is larger than the third nerve, firmer than the first, but less so than the second pair : it forms a kind of groove which receives the portio dura. The portio mollis and portio dura entering

* And we may add a third portion ; the portio mediâ of Wrisburg.

† “ Fosse de l'eminence olivaire,” of Vicq d'Azyr.

‡ Prochaska, speaking of the fourth ventricle, continues thus:—“ Super has ultimas eminentias solent medullares candicantes quasi fibræ decurrere, a quibus proprie originem portionis mollis nervorum auditorium saltem pro parte deducunt.” (Ridley, Haller, Lobstein, cum per antiquo auctore Piccolhomini et etiam recentissimus Soemmerring.—“ Ego postquam multoties in lineas illas medullares in quarto ventriculo inquisivissem, dicere possum, non semper illas in originem nervi acustici mollis terminare ; nonnunquam enim paulo supra nonnunquam paulo infra definunt, aliquando in uno latere, & haud raro utrinque desiderantur, ita ut ex his observationibus persuadear illas medullares quarti ventriculi strias ad originem portionis mollis nervi acustici minime essentielles esse.” Prochaska, tab. iii. f. f.

§ It is a curious circumstance, should future observation confirm it, which has been mentioned by Santorini, that those origins of the auditory nerve have been observed particularly strong in a blind man, whose hearing had been very acute.

The meatus auditorius internus of the petrous bone, the former is divided into four portions which pass to the several parts of the internal ear. The latter passes through the ear, and comes out by the stylo-mastoid foramen behind the ear, spreads upon the cheek, and forms the principal nerve of the face.

EIGHTH PAIR OF NERVES.

To understand a very intricate demonstration, it is necessary to recollect that the eighth pair of nerves, as they have a relation to the brain, consists of three distinct nerves.—These are, 1st, The GLOSSO-PHARYNGEAL NERVE; 2d, The PAR VAGUM; 3d, The spinal accessory.—Taken all together, they arise from the superior and lateral part of the medulla oblongata.

The GLOSSO-PHARYNGEAL NERVE is only distinguished within the skull as a larger filament of the eighth pair: it is however distinct in its course from the origin to the point where it pierces the dura mater; it is the uppermost of the fibres of this pair of nerves.—Sometimes there is a very delicate filament running parallel with its lower edge which belongs to it. It has the same origin with the fibres of the par vagum.*

The PAR VAGUM is composed of ten or twelve very small filaments, which are sometimes united into three or four fasciculi. These filaments arise from the outer border of the corpus olivare, or from the lateral part of the medulla oblongata.† Sometimes they arise in a double series like the nerves of the spine: a few fibres are to be traced from the side of the calamus scriptorius of the fourth ventricle.

The SPINAL ACCESSORY NERVE comes up from the spine to join the par vagum; it begins by small twigs from the posterior roots of the fourth, fifth, sixth, and even the seventh cervical nerves. In the size, length, and origin of those little slips, there is much variety: as the nerve ascends to the top of the spine, it connects itself with the suboccipital nerve; it then passes behind the trunk of the vertebral artery, approaches the

* Nervus glosso-pharyngeus fasciculo mox una, mox duabus, quatuor, quinque fibris composito oritur ex summa atque priore parte medullæ spinæ pone corpora olivaria nervum facialem inter atque nervum vagum, nonnunquam etiam ex quarto ventriculo vel ex cruribus cerebelli ad spinæ medullam, nonnunquam sub posteriori fulco nervi vagi, deductus ab eo vel distinctius, vel obscurius interposita arteria, vel vena, vel arteria et vena simul, vel parte plexus choreoidis, quid quod ipsa directione a nervo vago est distinctus." Soemmerring.

† Some filaments, according to Vieussens, Santorini, and Soemmerring, are derived from the paries of the 4th ventricle.

par vagum, and receives some filaments from the medulla oblongata.—Those three nerves, the glosso-pharyngeal, par vagum, and accessory nerves, in their passage out of the skull are connected in a very intricate way.* They there separate from each other. The anterior branch, the glosso-pharyngeal nerve goes to the tongue and pharynx; the middle nerve, the par vagum, has an extensive course through the body, and finally terminates into the stomach; the lowest nerve, the accessory, passing into the neck, perforates the mastoid muscle, and distributes its branches amongst the muscles of the shoulder.

NINTH PAIR OF NERVES; OR, LINGUAL.

THE ninth nerve of the skull originates from betwixt the corpora pyramidalia and olivaria. Like all the nerves of the spine, it is composed of several little filaments; those unite into a fasciculus of a pyramidal shape: still those filaments do not form a nerve before perforating the dura mater, but pierce it severally;† they then unite and pass out of the skull by the condyloid foramen of the occipital bone; they are then connected with the eighth pair and ganglion of the sympathetic nerve.—The final distribution of the nerve, is to the muscles of the tongue.‡

THE TENTH, OR SUBOCCIPITAL NERVE.

FROM its origin, its manner of passing betwixt the skull and first vertebra, and its distribution, it must be classed with the nerves of the spine.

The nerves of the spine are divided into the eight cervical, twelve dorsal, five lumbar, five, and sometimes six or seven, sacral nerves.§ Each of those twenty-five nerves arises in two fasciculi, one from the fore, and the other from the back part of the spinal marrow. They are to be traced a great way in

* The minutæ of which will afterwards call for attention.

† The ninth pair of nerves often differ very much in one side from the other, in regard to the origin and number of those fasciculi.

‡ “Forſan etiam nimio fanguine plena arteria vertebrali preſſus læditur, ut inde hæſitantia atque reſolutio linguæ ebriorum, ex cerebri phlegmone inſanientium, attonitorum explicari poſſit.—Collapſa vero eadem arteria ex nimio fanguinis profluſio lingua ob fanguinis forſan defectum reſolvitur. Ex ejuſdem nervi nexu cum nervis cervicalibus vocis jacturam poſt læſam ſpinalis medullæ partem quæ in cervice eſt, explicarunt.”

§ “Plerumque quinque ſunt, nonnunquam ſex, raro tres vel quatuor.” Soemmering.

the length of the spinal marrow before they pass the membranes. The posterior and anterior fasciculi penetrate the dura mater separately, and afterwards unite. The posterior fasciculi of the dorsal nerve before they unite with the other, swell into a little ganglion. The posterior fasciculi of the cervical nerves communicate with each other by intermediate filaments.

END OF THE ANATOMY OF THE BRAIN.

CHAP IV.

OF THE PARTICULAR NERVES.



THE FIRST PAIR OF NERVES ; OR, OLFACTORY NERVES.

WE have described the three roots of this pair of nerves : their triangular form, their bulbous extremities, and their manner of perforating the cribriform plate of the æthmoid bone.

Where the soft and pulpy-like mass of the olfactory nerves perforates the æthmoid bone, the dura mater involves them and gives them firm coats.* There are two sets of nerves ; first, Those which pass through the holes in the cribriform plate, nearest the crista galli; run down upon the septum of the nose, under the schneiderian membrane, and betwixt it and the periosteum. They become extremely minute as they descend ; and they, finally, pass into the soft substance of the membrane. Secondly, Those filaments which pass down by the outer set of holes of the æthmoid plate, are distributed to the membrane investing the spongy bones.

Although branches of the ophthalmic, pterigoid, palatine, and suborbital nerves pass to the membrane of the nose, there is reason to believe that they have no power of conveying the impression of odours. These nerves are necessary that the membrane may possess the common properties bestowed by the nerves.

Upon the question, whether those additional branches of nerves to the nose, assist in conveying the impression of odours, there has been much controversy. It is a subject upon which we might reason by analogy ; but, certainly, little dependence can be placed upon those cases brought by either party, of diseases affecting the one set of nerves without influencing the other. From the nature of the parts, ulceration or tumors, which destroy the bones of the nose, must press equally upon the branches of the olfactory nerve, and of the fifth pair. We find that there pass also to the other organs of sense, subordi-

* Duvcrney first observed this course and firmness of the olfactory nerves.

nate nerves ; and we know that a nerve may be modified to much variety of function ; and this is evident from the nerve of taste being a branch of the fifth pair. But it is doubtful how far a nerve may be capable of receiving at one instant various impressions. Far from considering distinct nerves sent to the same organ, as affording an argument for these nerves receiving one uniform impression, and conveying one simple sensation, it would seem more rational to infer, that one individual nerve cannot perform two functions, and that two functions are often required in the organs of sense. I am inclined to believe, that the olfactory nerve is incapable of bestowing common sensation on the membrane of the nose ; and that the other nerves which ramify on that membrane, do, on the other hand, contribute nothing to the sense of smell, as we find that the inflammation of the pituitary membrane, which raises the sensibility of the branches of the fifth pair of nerves, does in ~~no~~ degree make those of the olfactory nerve less acute. The membrane is painfully inflamed, but the sense of smell is deadened. In attending to the delicate sensibility of the nerves of the senses, we neglect to take into account the less prominent, but no less curious peculiarities in the sensations, and sympathies of the common nerves. The senses of taste or smell are not more distinct from each other, or from common sensation, than are the peculiar sensations which belong to the sensibility of the several viscera. The stomach and intestinal canal possess as great a discriminating power as the organ of taste, although the sensations are less perfectly conveyed to the sensorium. There is a variety in the susceptibility of the several organs and viscera, a distinct sensation and proportioned action and election which is essential to the order and œconomy of the general system. This is conspicuous in the variety of the affections in remote parts, when food, medicine, or poison is received into the body. These peculiarities in the impression of which each organ is susceptible, are so far distinct as to be essential to the due excitement of that organ ; and are yet so general, as to connect, in one combined action, the whole system, and to occasion sympathies in remote parts, which perplexes, and give that degree of intricacy to the living actions, which renders medicine an uncertain art.

ARRANGEMENT OF THE NERVES PROCEEDING FROM THE CRANIUM.

The first nerve we have seen passing to the nose.

The second, third, fourth, part of the fifth and sixth, pass to the eye, or through the orbit.

The seventh nerve is that which becomes the organ of hearing.

Part of the fifth, seventh, eighth, ninth, and suboccipital nerves pass to the bones of the face, the integuments and muscles of the face, the jaw, and throat.

From the sixth pair of nerves is derived the great sympathetic; from the eighth is sent downwards the par vagum.

The extreme branches of the fifth pair, of the seventh, of the eighth, ninth, and first cervical nerves, form a chain of connections, surrounding the head, face, and neck.

SECOND PAIR, OR OPTIC NERVES.

In this part of the work there is no occasion to deliver any thing further concerning the optic nerves, than has been already said of their origin, and final expansion in the retina of the eye. It will be more proper to consider them fully when treating of the eye in particular.

THIRD PAIR OF NERVES, OR MOTORES OCULORUM.

These nerves have the name of *motores oculorum*, because they are distributed to the muscles which move the eye-balls. They pass upwards from their origin; and then diverging, they penetrate the dura mater under the extreme point of the tentorium; they descend again by the side of the cavernous sinus, and pass out of the cranium by the foramen lacerum of the sphenoid bone.

The *nervus motor oculi* having come into the socket divides into two branches: the *INFERIOR BRANCH* passes forward along the outside of the optic nerve; it then divides into these branches:

1. To the adductor muscle.
2. To the rectus inferior.
3. To the external oblique and to the lenticular ganglion.

But the branch of the third nerve, which, with the fifth, forms this little ganglion, is, by no means, constantly derived from this branch. The *LESSER and SUPERIOR BRANCH* of the third, is distributed to the rectus superior oculi and levator palpebræ superioris.

FOURTH PAIR OF NERVES, TROCHLEARES, OR PATHETICI.

These nerves are very small. Their origin, from about the tubercula quadrigemina, and their long course under the base of the brain, have been already described; after proceeding a

considerable way, in cases in the duplicature of the dura mater, where it forms the extreme point of the tentorium, they pass amongst the lamellæ of the dura mater, where it forms the cavernous sinus. They pass by the outside of the third pair of nerves; turn round so as to be above them, and make their egress through the foramen lacerum of the sphenoid bone.— They pass forward in the orbit, undiminished by the giving off of branches; and are each finally distributed to the superior oblique muscle or trochlearis. Sometimes, however, in their course, they send branches to unite with those of the fifth pair, which pass to the nose, or even to the frontal nerve; but this is very rare.*

As this nerve is derived very far back from the brain, and as the parts from which it originates are less affected by the distention of the ventricles than almost any other part of the brain, this may be a reason why in hydrocephalus we so frequently see the eyes turned obliquely towards the nose. The origins of these nerves being less affected, they will give a comparatively greater power to the superior oblique muscle. It has been observed also, that in death the power of the superior oblique muscle has a preponderance.

THE FIFTH PAIR, OR TRIGEMINI.

The tracing of the branches of the fifth pair, by dissection, is a difficult task, for those branches are distributed among the bones of the face, to the eyes, nose, mouth, tongue, and throat. From this extensive distribution the fifth nerve is necessarily the largest of those that pass out of the cranium.

It is of a flattened form; † it penetrates the dura mater at the anterior point of the petrous bone, and spreads flat under it. Here, under the dura mater, it is matted into one irregular ganglion; viz. the semilunar, or Gasserian ganglion. This ganglion lies on the anterior point of the temporal, and on the sphenoidal bone. In their passage from the brain, the filaments, composing the fifth nerve, are loose, or easily separated; at this place, they are all found so subdivided and entangled, as to resist further division. The nerve here swells out into a greater size; it seems to be incorporated with the dense fibres of the dura mater; it becomes of a dark red, or mixed colour; all which circumstances have, by no means, been unobserved by anatomists. Vieussens supposed, that the use of this ganglion of the fifth pair, before it perforates the cranium, was to strengthen the nerve, and enable it to withstand the motion of

* Soemmerring.

† So it is said, by Mickel, to resemble the flat worm, or *taenia*.

the jaws ! But it would rather seem to be a ganglion connecting in sympathy all those parts to which the nerve is finally distributed.*

The connection of the Gasserian ganglion with the dura mater, is so firm, that it yet remains undecided, whether there are sent off here any nerves to that membrane ; but I conceive, that there are none, and that the connection of the ganglion with the fibrous membrane, or sheath which covers it, has been mistaken for nerves passing from the ganglion to the dura mater.

From the semilunar or Gasserian ganglion, the fifth nerve divides into three great branches ; whence the name of trigemini :

1st, The OPTHALMIC BRANCH of WILLIS, which passes through the foramen lacerum into the orbit.

2d, The SUPERIOR MAXILLARY NERVE, which passes through the foramen rotundum.

3d, The INFERIOR MAXILLARY NERVE, which passes to the lower jaw, through the foramen ovale.

The ophthalmic branch of the fifth pair.

This nerve enters the orbit in three divisions ; these are, the *frontal*, the *nasal*, and the *lachrymal* nerves.

1st, The first of these runs under the periosteum of the upper part of the orbit, and above the levator palpebræ superioris. Upon entering the orbit it gives off a small branch, which passes to the frontal sinus ; the nerve then divides into the super trochlearis, and the proper frontal nerve. The first of these passes to the inner part of the orbicularis oculi and frontal muscle. The other, the outermost, and the proper frontal nerve, passes through the hole, or notch, in the margin of the orbit, and mounts upon the muscles and integuments of the forehead. These superficial branches communicate with the extreme branches of the portio dura, or nervus communicans faciei.

Cases are on record of wounds of the frontal nerve occasioning a great variety of nervous symptoms, and especially loss of sight ; and it certainly marks a very particular connection and sympathy betwixt this branch and the common nerves which pass to the eye-ball and iris, and the retina, that blindness is actually occasioned by the pricking of the frontal nerve.—Morgagni supposes this to be occasioned by the spasmodic

* "Et affectum animi indicia in faciei partibus depingere adjuvet." Hirsch. Sand. Thes. Diferta, p. 491.

action of the recti muscles pressing the globe of the eye down against the optic nerve. It is also remarkable, that impressions acting solely on the retina, will convulse the muscles of the eye, give them irregular contractions, and consequently distort the eye-ball and produce blindness. Such has been found to be the effect of lightning in some instances.

2d, The NASAL BRANCH of the ophthalmic nerve sends off a slip or twig to form with a branch of the third pair, the LENTICULAR OR OPHTHALMIC GANGLION; while the trunk of the nerve passes obliquely forwards, and inward through the orbit, and gives off one or two extremely small twigs, which join the fasciculi of ciliary nerves. The nasal branch then continues its course betwixt the superior oblique and adductor-muscles; before piercing the orbital plate, it sends forward a branch, which passing under the pulley of the superior oblique muscle, joins that division of the frontal nerve which passes over the pulley. The nasal nerve then passing through the internal orbital foramen, enters the scull again, and runs under the dura mater, which covers the æthmoid bone, to pass through the cribriform plate of that bone, and again to escape from the cranium. It is finally distributed to the upper spongy bones, and to the frontal sinuses.

We thus observe such a connection of the nerves of the eye and nose, and of those distributed to the inner angle of the eye, and muscles of the eye-lids, as sufficiently accounts for the sympathy existing among those parts. We see the necessity of this connection, since the excitement of the glands which secrete the tears, the action of the muscles, and the absorption of the tears into the nose, must constitute one sympathetic action.

The LENTICULAR, OR, OPHTHALMIC GANGLION, comes naturally to be considered under this division of the fifth pair. The lenticular ganglion is formed by a twig from the nasal branch of the fifth pair, after being united to that branch of the third pair of nerves, which goes to the levator palpebræ and the rectus superior muscles. The ganglion is of a square form, and is situated upon the outside of the optic nerve. The ciliary nerves pass out from this ganglion into two fasciculi; they are ten or twelve in number; they are joined by branches of the continued nasal nerve. The ciliary nerves run forward amongst the fat of the orbit, to the sclerotic coat of the eye, and pierce it very obliquely in conjunction with the ciliary arteries. The ciliary nerves and arteries then pass forward betwixt the sclerotic and choroid coats of the eye to the iris. The iris is considered as the part the most plentifully supplied with nerves (as it certainly is also with arteries) of any

part in the body. It follows, indeed, from what we formerly said, that a profuse circulation of blood is necessary to an accumulated nervous power.

From the connection of these ciliary nerves with those passing to the nose, Soemmerring accounts for sneezing being the consequence of a strong light upon the eye. This may perhaps be true; but, certainly, the temporary loss of light, from sneezing, does not depend upon this connection of the nerves, but upon the immediate affection of the optic nerve and retina, from the concussion and interruption to the circulation, or upon the accumulation of blood in the eye.

2. The LACHRYMAL NERVE is the least of the three divisions of the ophthalmic nerve; it divides into several branches before it enters the gland. Several of these branches pass on to the tunica conjunctiva, being joined by twigs of the first branch of the superior maxillary nerve. Others connect themselves with the extremities of the portio dura of the seventh pair, and with the superior maxillary nerves.

The second branch of the fifth pair; viz. the superior maxillary nerve.

The superior maxillary nerve, having passed the foramen rotundum, emerges behind the antrum highmorianum, at the back part of the orbit, at the root of the pterigoid process of the sphenoid bone. The infra orbital canal lies directly opposite, and ready to receive one branch, while the speno-maxillary, opening into the orbit, is above, ready to receive another. The chief part, or trunk, of the nerve may be said to be seated, and to give out its divisions in the pterigo-palatine fossa. Through the speno-maxillary hole, the first branch of the superior nerve is sent into the socket of the eye. This twig unites with branches of the lachrymal nerve, and in general supplies the periosteum of the orbit. It then sends, through the foramen in the os mallæ, a branch which is distributed to the orbicularis muscle of the eye-lid, and communicates with the branches of the portio dura of the seventh pair, or nervus communicans faciei. Another branch of this first division passes upwards from the zygomatic fossa, in a groove of the wing of the sphenoid bone, to the temporal muscle, and getting superficial, it accompanies the branches of the temporal artery.

Independently of this branch, which passes upwards to the temporal muscle, Miel, in his first dissertation on this nerve, divides its branches into four: 1st, The infra orbital; 2d, The descending branch, which again gives off the vidian

and nasal nerves ; 3d, The palatine nerve and posterior alveolar nerve. It was not till afterwards that he discovered the ganglion which takes his name ; and, of course, the previous description must be imperfect. The superior maxillary nerve, after sending off the small branches which I have described to enter the orbit, having fairly emerged out of the cranium, sends down two small branches which, uniting, form a little ganglion of a reddish colour, and of a triangular shape, like a heart. This, the SPHENO-PALATINE GANGLION, or ganglion of Mielk, is exactly opposite to the spheno-palatine hole ; and those nerves, and this ganglion are immersed in the soft fat which fills up the space betwixt the sphenoid palatine and superior maxillary bones.

From this ganglion are sent out several lesser nerves, and particularly the nasal, vidian, and palatine nerves.

The SUPERIOR NASAL BRANCHES pass by the spheno-palatine hole to the membrane on the back part of the nose, and to the cells of the sphenoid bone, through the spheno-palatine hole.

The VIDIAN NERVE comes off from the back part of the ganglion, and passes into the foramen pterigoideum backwards. It first gives off some small branches to the nose (the superior and posterior nasal nerves of Mielk) ; these perforating the bone laterally, are distributed on the pituitary membrane, covering the vomer. The vidian nerve continuing its course backwards, splits ; one branch, after a long retrograde course through the petrous part of the temporal bone, forms a connection with the portio dura, while the other forms one of the roots of the great sympathetic nerve, by joining the branch of the sixth pair, which passes down with the carotid artery.

From the distribution of this branch of the fifth pair to the membrane of the nose, and its connection with the sympathetic, some physiologists account for the effects of odours in causing fainting, as the chief nerves of the heart are received from the sympathetic. They also account thus for the excitement of the heart, in deliquium, by stimulant applications to the nose.

The PALATINE NERVE is the largest of the branches sent out from the ganglion. We have to recollect, that there are two canals passing down behind the palate ; one anterior and larger ; and another running nearly parallel to it, a posterior and smaller one. The division of the palatine nerve, which descends through the anterior palatine hole, is of course the larger branch ; as it passes through the canal, it gives branches which enter the nose, to be distributed upon the pituitary membrane. This larger branch, in its further progress

through the bone, divides, and having emerged from its hole is distributed all along on the left palate. The posterior division of the palatine branch, passing down by the posterior palatine foramen, is distributed to the velum pendulum palati and its muscles.

There is yet a third branch of the palatine nerve; *viz.* the external palatine nerve. It is the least of all the branches; and, sometimes, instead of coming from the ganglion, is derived immediately from the superior maxillary nerve. This branch descends before the pterigoid processes, and on the convex surface of the upper maxillary bone, and is distributed to the velum palati and uvula.

The superior maxillary nerve, after sending off the branches which form the spheno-palatine ganglion, passes obliquely downwards to the infra orbital canal. In this course it gives off the posterior nerve to the teeth of the upper jaw; and this again gives off a twig, which takes a course on the outside of the maxillary bone, and supplies the gums and alveoli, and buccinator muscle.

While passing in its canal, the infra orbital nerve gives off the anterior nerve to the teeth; and when it emerges from the infra orbital foramen, it spreads widely to the muscles of the face, connecting itself with the extremities of the portio dura of the seventh pair, or nervus communicans faciei.

The "tic douloureux," and the "tic convulsif," of the French authors, are diseases attributed to the affection of this nerve. The seat of the tic douloureux, is the side of the face, the nostril, the cheek-bone, and root of the alveoli. Sauvage calls it the trismus dolorificus, or maxillaris. But it is a disease not absolutely fixed to this point of the cheek-bone; but on the contrary, from the universal connection betwixt the nerves of the face, it takes, sometimes, a wide range; and the disease, I have no doubt, is sometimes seated in the portio dura of the seventh pair. Sauvage has given to one species of it, the name of occipitalis.

It is a disease attended with extreme pain, which forces the patient to cry out in great agony. The pain is felt deep rooted in the bones of the face, and seems to spread upon the expanded extremities of the nerve; it is sudden, violent, and reiterated in its attack, and it varies in the length and repetition of its accession. It is confined chiefly to those advanced in years, and is as violent in the day as during the night; and in the advanced state of the disease, when the face is swelled, the slightest touch will excite the pain.

This disease is apt to be confounded with the affection of the antrum highmorianum, the tooth-ach, rheumatism, and clavis

hystericus, or even with venereal-pains. It has been cured by dividing the infra orbital nerve.

In hemicrania, the affection of the three branches of the fifth nerve, is such as to mark their distributions. There is swelling and pain of the face, pain of the upper maxillary bone, pains in the ear and in the teeth, difficulty of swallowing, and lastly, stiffness in moving the lower jaw, in consequence of the affection of those branches which pass up to the temporal muscle.

There are cases spoken of by Sabbatier, where this infra orbital nerve being wounded, unusual nervous affections, and even death, were the consequence: but it would rather appear, that, independently altogether of the affection of the nerves of the face, inflammation spreading from the wound to the brain, had, in the examples which he gives, been the occasion of the unusual symptoms, and of the death of the patients.

Third branch of the fifth pair; or, lower maxillary nerve.

This, the last of the three great divisions of the fifth pair of nerves, the largest but the shortest branch within the scull, passes out by the foramen ovale. It is distributed to the muscles of the lower jaw, tongue, and glands. The trunk of the nerve having escaped from the cranium, lies covered by the external pterigoid muscle; and is at this point divided into two great branches, which again subdivide into numerous small branches; many of which it would be superfluous to describe. It is sufficient to mention them as going, 1, to the masseter muscle; 2, to the zygomatic fossa and temporal muscles; 3, to the buccinator muscle.

We regard as the two greater divisions of the lower maxillary nerve; first, The proper nerve which passes into the lower jaw; and, secondly, The gustatory or lingual nerve. The division into these two great branches is formed, after the nerve has passed betwixt the pterigoid muscles.

The GUSTATORY NERVE, immediately after its separation from the nerve of the lower jaw, is joined by the chorda tympani; or, perhaps we should rather say, a branch of this nerve, by traversing the petrous portion of the temporal bone in a retrograde direction, unites itself with the portio dura of the seventh pair, as it is passing through the ear. This nerve, being seen passing across the tympanum, is the reason of its being called, CHORDA TYMPANI. The gustatory nerve, proceeding obliquely downward, sends off twigs to the salivary glands and muscles, situated betwixt the jaw-bone and tongue.—Where it is passing by the side of the maxillary gland, it gives

out some filaments which form a small ganglion, from which branches penetrate the gland. The trunk then proceeding onward betwixt the sublingual gland and the musculus hyoglossus, several twigs are sent off, which form a kind of plexus amongst the muscles and salivary glands; and communicating with the ninth pair of nerves, are distributed, finally, to the gums and membrane of the mouth.

The gustatory nerve terminates in a lash of nerves, which sink deep into the substance of the tongue, betwixt the insertion of the stylo and genio-glossal muscles. These pass to the papillæ on the surface of the tongue. The sense of taste, the impression of which is received upon this nerve, is seated in the edge and anterior part of the tongue: the action of the tongue against the palate forces the sapid juice of the morsel to extend to the edge of the tongue.

The proper lower maxillary nerve, which enters into the lower jaw-bone, sometimes called, *mandibulo labralis*, passes downward in an oblique direction to the groove of the lower jaw-bone. Before this nerve enters the canal of the bone, it gives off branches to the mylo-hyoideus and digastricus, to the submaxillary glands and to the fat. The nerve then entering the bone, runs its course all the length of the lower jaw within the bone, and comes out at the mental hole. In this course it gives branches which enter the roots of the teeth, and accompany the branches of the arteries. When this lower maxillary nerve has escaped from the mental hole, it divides into two branches upon the chin; one of these is distributed to the orbicularis and depressor anguli oris, and to the skin and glands of the lips; the other to the depressor labii inferioris and integuments, and forms a kind of plexus, which surrounds the lips. These nerves are also connected with the wide spreading branches of the portio dura of the seventh pair; and they are the lowest branches of the facial nerves, and the last enumerated of the intricate branches of the fifth pair.

THE SIXTH PAIR OF NERVES; ABDUCENTES, OR MOTORES EXTERNI.

The sixth pair of nerves, as we have seen, arises betwixt the tuber annulare and the corpus pyramidale. Advancing forwards and upwards, sometimes above and sometimes beneath the branches of the basilar artery, it penetrates the dura mater by the side of the basilar sinuses. It then passes by the side of the carotid artery, and through the cavernous sinus.—Here it gives off filaments, which, clinging to the carotid artery, descend with it until they are joined by a branch of the

vidian nerve. These together form the origin of the great sympathetic nerve. It is a disputed point, however, whether this be a branch given out from, or received into, the sixth pair; and in the description of the sixth pair, we might say, that as it passes the carotid artery, it receives one or more nerves which come up through the carotid hole, and encircle the nerve. The sixth pair enters the orbit by the foramen lacerum, with the third and fourth pairs, and first branch of the fifth. It pierces the abductor muscle of the eye before it is finally distributed to its substance.

It has been presumed, that the sixth nerve does not give off the sympathetic nerve, but receives those branches from it, because the sixth nerve is larger betwixt this point and its distribution in the orbit, than betwixt the same point and its origin from the brain. But I conceive, that this enlargement of the sixth pair is not owing to such a junction; but that, on the contrary, the nerve naturally swells out when it enters the sinus, not from being soaked in the blood of the sinus, but from its having additional investing coats, or from the coats being strengthened in order to prepare the nerve for its passage through the blood of the sinus.

Again, that the sympathetic nerve sends up those branches to join the sixth, has been presumed from the effects of experiments on animals, of cutting or of bruising the sympathetic nerve. But I should not be apt to give implicit credit to the result of these experiments. Supposing that the sympathetic in the neck gave an origin to the sixth pair, should not paralysis of the abductor muscle of the eye, and in consequence of this, the turning of the eye towards the nose, be the effect of cutting the sympathetic?

We shall probably cease to dispute this point, when we consider the relations and use of the sympathetic nerve.

The nerves cannot be considered in any other light than as being formed of the same matter with the brain, as having similar functions and powers, rather co-existing than dependent on the brain: and the sympathetic nerve may be defined, a tract of medullary matter, passing through and connecting the head and neck, the viscera of the thorax, abdomen, and pelvis, into one whole.

The sympathetic nerve is singular in this, that it takes no particular origin, but has innumerable origins, and a universal connection with the other nerves through all the trunk of the body. Those viscera to which it is distributed are entirely independent of the will, and have functions to perform too essential to life to be left under the influence of the will. The sympathetic nerve is thus, as it were, a system within itself, having

operations to perform of which the mind is never conscious ; whilst the extent of its connections occasion, during disease, sympathetic affections not easily scrutinized.

The function of this nerve is thus, in a great measure, insulated from the brain. The operations connected with it proceed, even when the brain is wanting ; and it is impossible seriously to consider the sixth nerve as giving the origin to the sympathetic in any other light, than as such an expression may be subservient to arrangement, description, and general enumeration of the nerves ;—a thing most necessary in so intricate a piece of anatomy.

OF THE SEVENTH PAIR OF NERVES.

The nerves of the seventh pair consist each of two fasciculi, which arise together, and pass into the meatus auditorius internus.* But these portions do not pass through the bone in union ; for the anterior and lesser fasciculus, is a common nerve, which passes through to the face, and is invested, like the common nerves of the body, with strong coats. It is therefore called the PORTIO DURA.† The more posterior fasciculus is the auditory nerve, and is distributed to the organ within the pars petrosa of the temporal bone ; and in distinction it is called the PORTIO MOLLIS.

The PORTIO DURA, or NERVUS COMMUNICANS FACIEI, in passing from the brain to the internal auditory foramen, is lodged in the fore part of the auditory nerve, as in a groove.—When it leaves the auditory nerve, it passes on through the bone, and emerges on the side of the face through the stylo-mastoid foramen at the root of the styloid process, so as to come out just under the tip of the ear, covered, of course, by the parotid gland. This portio dura, while passing through the canal of the temporal bone (which is the aqueduct of Fallopius,) gives off a branch which unites with the vidian nerve of the fifth pair ; or rather, we may conclude with the best authors, that it receives a branch which comes retrograde from the vidian nerve, passing through the small hole on the anterior surface of the petrous part of the temporal bone. The portio dura, when it has proceeded onwards by the side of the tympanum, gives off one or more very minute branches to the

* The intermediate filaments of Wrisberg, which is betwixt these two portions of the seventh nerve, is afterwards united to the portio dura, and must be considered as one of its roots.

† Galen divided all the nerves of the brain into those two classes, *mollis* and *dura* ; of which the first were those of the senses, the latter the motores corporis.

muscles within the tympanum, which give tension to the small bones of the ear. A little further on, this nerve gives off a more remarkable branch, which, passing across the tympanum, is called *CORDA TYMPANI*. This is the branch which, as we formerly mentioned, joins the gustatory branch of the lower maxillary nerve. The *corda tympani* passes through the tympanum betwixt the long process of the incus and the handle of the malleus; then, received into a groove of the bone, it passes by the side of the eustachian tube, and after enlarging considerably, it is united with the gustatory nerve.

When the *portio dura*, or *nervus communicans faciei*, has escaped from the stylo-mastoid foramen, but is yet behind the condyle of the lower jaw, and under the parotid gland, it gives off, 1st, The posterior auris. This has connection with the first cervical nerve, and passing up behind the ear, it is connected with the occipital branches of the third cervical nerve. 2d, The *nervus stylo-hyoideus* to the styloid muscles, and to unite with the sympathetic. 3d, A branch which supplies some of the deep muscles, and joins the laryngeal branch of the eighth pair.

The *portio dura*, rising through the parotid gland, spreads out in three great divisions:

1. An *ASCENDING BRANCH*, which divides into three temporal or jugal nerves; so called, because they ascend upon the jugum, or zygomatic process. Two orbicular nerves, which, passing up to the orbicularis muscle, branch upon it, and inosculate with the extremities of the fifth pair.

2. The *FACIAL NERVES*. The superior facial nerve passes out from the upper part of the parotid gland, across the face to the cheek and orbicularis muscle of the eye. The middle facial nerve passes from under the *risorius santorini*; it goes under the zygomatic muscle, and encircles the facial vein; it sends branches forward to the lips, and upwards to the eyelids, and to unite with the infra-orbital nerve. There is an inferior facial nerve, which comes out from the lower part of the parotid gland, passes over the angle of the jaw, and is distributed to those fibres of the *platysma myoides* which stretch up upon the face, and form the *risorius santorini*: it passes on to the angle of the lips, and is distributed to their depressor muscle. Betwixt those facial nerves there are frequent communications, while they are at the same time united with the extremities of several branches of the fifth pair.

3. The *DESCENDING BRANCHES* pass along the margin of the jaw, down upon the neck, and backward upon the occiput. Thus we see that the communicating nerve of the face is well named.—It is distributed to the side of the face, head, and up-

per part of the neck : it unites its extreme branches with those of the three great divisions of the fifth pair, with the eighth and ninth, with the accessory of the eighth pair, with the second and third cervical nerves, and with the sympathetic. From those various connections it has been called the lesser sympathetic. As to the sympathies which physicians have thought fit to ascribe to the connections of this with other nerves, as laughing, weeping, kissing, &c. they would be tedious to enumerate, and by no means instructive.

The *PORTIO MOLLIS* of the seventh pair of nerves is the acoustic or auditory nerve; which shall be considered in a more distinct and particular manner, when we describe the other parts of the organ of hearing.

The nerves which we have now described are connected with the anatomy of the head, and circulate chiefly around the bones of the face. Those we are next to consider extend their branches to the neck, and form there a very intricate piece of anatomy, while a class of them still more important, pass down to the viscera of the breast and belly.

THE EIGHTH PAIR OF NERVES.

THE fasciculus, which, proceeding from the medulla oblongata, passes out of the cranium by the side of the great lateral sinus, and which, in the view we have of the nerves upon raising the brain from the cranium, is properly enough considered as the eighth pair, consists in truth of three distinct nerves. These are the *GLOSSO-PHARYNGEAL NERVE*, the *PAR VAGUM*, and the *SPINAL ACCESSORY NERVE OF WILLIS*.

THE GLOSSO-PHARYNGEAL NERVE.

This nerve, parting from its connection with the par vagum and accessory nerves, perforates the dura mater separately from these, and in many subjects, passes through an osseous canal distinct from the par vagum. When it escapes from the cranium, it lies deep under the angle of the jaw, and passes across the internal carotid artery upon its outer side. It is to be seen by lifting the styloid muscles, at which point it sends small branches to the styloid and digastric muscles, and to join the par vagum. It sends also some very small twigs down upon the internal carotid artery; some of which join

that pharyngeal branch* which is formed from the par vagum and accessory nerve.

These branches united form a small irregular ganglion, from which again pass off numerous branches to the constrictor muscles of the pharynx.

The trunk of the glosso-pharyngeal nerve, after giving off those nerves which pass in the direction of the internal carotid artery, continues its course attached to the stylo-glossal and stylo-pharyngeal muscles, to which of course it gives more branches, and also to the upper division of the constrictor pharyngis. A division of the extreme branches of this nerve terminates in the tongue, under the denomination of *rami linguales profundi*, *rami linguales laterales*, *nervi glosso-pharyngei*.†

It appears to me that these branches are distributed amongst the short muscles of the tongue, and perhaps to the large papillæ upon the most posterior part of the tongue. Amongst the branches of the pharyngeal nerve is to be enumerated that which turns back to join the ninth pair in its distribution to the tongue.‡ The remaining branches of the glosso-pharyngeal nerve, are distributed in innumerable filaments upon the pharynx, in which they are assisted by branches from the ganglion of the sympathetic nerve.

THE PAR VAGUM.

THE par vagum is the great and important division of the eighth pair. It is the middle fasciculus of the three nerves as they lie within the scull. In its exit, it is separated from the internal jugular vein by a thin bony plate; and sometimes two or three fibres of the nerve pass the bone distinct from the others, and afterwards unite into the proper trunk of the par vagum. Deep under the lower jaw and the mastoid process, the glosso-pharyngeal nerve, the par vagum, the spinal accessory, the sympathetic nerve, the portio dura of the seventh, and the upper cervical nerves are entangled in a way which will fatigue the dissector, and may account for every degree of sympathy of parts. The par vagum, lying behind the internal carotid artery, and as it were escaping from the confusion

* This is a branch to the pharynx which is formed by the par vagum and the spinal accessory of Willis. After this nerve is formed, it again forms a connection with the par vagum.—Pain in the throat having been observed by Galen to extend to the back, Scarpa explains it on the ground of this connection with the spinal accessory nerve.

† Scarpa.

‡ Sabbatier.

of the ninth, accessory and glosso-pharyngeal nerves, descends and swells out into a kind of ganglion.* We now observe three branches to be sent off: The FIRST and SECOND PHARYNGEAL NERVES, which pass to the constrictor pharyngis muscle, and the INTERNAL LARYNGEAL NERVE. This last mentioned nerve is even larger than the glosso-pharyngeal nerve. It is behind the carotid artery, and passes obliquely downward and forward. In its progress the principal branch passes under the hyo-thyroideus muscle, and betwixt the os hyoides and the thyroid cartilage; while others, more superficial, pass down and are connected with the EXTERNAL LARYNGEAL, OR PHARYNGO-LARYNGEUS; which is a nerve formed by the sympathetic, and par vagum conjointly. The principal branch of the internal laryngeal nerve which runs under the hyo-thyroideus, is distributed to the small muscles moving the cartilages. The minute extremities of this nerve pass also to the apex of the epiglottis, and the glandular membrane covering the glottis. We have, at the same time, to remark a very particular communicating nerve betwixt this internal laryngeal nerve, and the recurrent branch of the par vagum. This branch is described by Galen. The par vagum continues its uninterrupted course betwixt the carotid artery and jugular vein, and is involved in the same sheath with these vessels. In this course down the neck, it sometimes sends back a twig which unites with the ninth pair, and when near the lower part of the neck, it sends forward twigs to unite with those from the sympathetic nerve, which pass down to the great vessels of the heart, to form the superior cardiac plexus.† On the right side, those nerves to the great vessels are in general given off by the recurrent nerve.

The par vagum now penetrates into the thorax by passing before the subclavian artery; it then splits into two. The main nerve passes on by the side of the trachea, and behind the root of the lungs; while the branch, on the right side, turns round under the subclavian artery; on the left, under the arch of the aorta, and ascends behind the trachea to the larynx.

This ascending branch of the par vagum is the RECURRENT NERVE. On the right side it is sometimes double. It ascends behind the carotid artery, and sometimes is thrown round the root of the thyroid artery. On the left side, which from its turning round the arch of the aorta, is much lower than on the

* *Truncus gangliiformis* OCTAVI, *tumidulum corpus olivare*, Fallopii; but it is suspected that in this he meant the ganglion of the sympathetic nerve.

† The course of these nerves to the heart, is best treated of with the branches of the sympathetic nerve.

right, it gives off filaments which go to the lower cardiac plexus, after having united with the branches of the sympathetic. Under the subclavian of the right side, also, there are sent branches from the recurrent to the cardiac plexus: and on both sides there pass branches of communication betwixt the sympathetic nerve and the recurrent. When the recurrent nerve has turned round the artery, it ascends in a direction to get behind the trachea, and it lies betwixt the trachea and œsophagus. It here sends off many branches to the back and membranous part of the trachea which pierce this posterior part, to supply the internal membrane. It gives also branches to the œsophagus and thyroid gland. The final distribution of this nerve is to the larynx. It pierces betwixt the thyroid and cricoid cartilages, and separates into many filaments, which terminate in the crico-arytenoideus lateralis and posticus, and thyro-arytenoideus, and in the membrane of the larynx. We have already mentioned the branch of communication betwixt the recurrent and internal laryngeal nerves,* and Sabbatier describes a branch of the recurrent, which sometimes ascends and joins the sympathetic high in the neck.

Two cases, mentioned by Galen, of scrophulous tumours in the neck opened, where the consequence was loss of voice, have tempted many anatomists to institute experiments on the recurrent and internal laryngeal nerves.† Notwithstanding the deep situation of those recurrent nerves, Galen says, they were cut in these cases, and he believed that the branch of communication betwixt the laryngeal and recurrent restored the voice after some time had elapsed. Both the internal laryngeal and recurrent nerves are necessary to the formation of the voice. Experiments have been made upon them in dogs, and the result is curious; although the lesser changes of the strength, acuteness, and modulation of the voice could not be well observed in the lower animals. When the laryngeal nerve is cut, the voice is feeble but acute; when the recurrent nerve is cut, there is a relaxation of those muscles moving the arytenoid cartilages which command the opening of the glottis, and in consequence the voice is flatter or graver, or more raucous.

The par vagum, after sending off the recurrent nerve, descends by the side of the trachea. Before it passes behind the

* There is a double communication betwixt those nerves; in the first place by this more superficial branch, and again by several internal and more minute branches.

† Martin, in the Edinburgh Essays, Professor Sue of Paris, Dr. Highton, in the memoirs of the Medical Society of London; Cruikshanks, Professor Scarpa, Arnemann, &c.

vessels and branch of the trachea going to the lungs, it sends minute branches which form the ANTERIOR PULMONIC PLEXUS.* This plexus is entangled in the connections of the pericardium, and is dissected with difficulty. The branches of this plexus throw themselves round the pulmonic arteries and veins, and follow them into the lungs.

The par vagum, passing on behind the root of the lungs, forms the POSTERIOR PULMONIC PLEXUS. From this also the nerves proceed into the lungs, by attaching themselves to the pulmonic arteries and veins, and bronchial arteries, and the branches of the trachea.†

The trunks of the nerve, continuing their course upon each side of the œsophagus, unite and split into branches, and again unite so as to form a netting upon the œsophagus; these are the ANTERIOR and POSTERIOR PLEXUS GULÆ, or OESOPHAGEAL PLEXUS. The par vagum, thus attached to the œsophagus, pierces the diaphragm with it, the anterior plexus unites again into a considerable trunk, is attached to the lesser arch of the stomach. It stretches even to the pylorus, and sends its branches to the upper side of the stomach and to the lesser omentum; at the same time it unites with the left hepatic plexus, some of its branches terminate in the solar plexus, which surrounds the root of the cæliac artery. The posterior œsophageal plexus, likewise uniting again into a considerable cord when it has come into the abdomen, sends branches to encircle the cardiac orifice of the stomach; it branches also to the inferior side and great arch of the stomach; it sends also branches to the splenic plexus and solar ganglion.

* I do not conceive that this plexus admits of any useful division, or requires any distinction of name.

† *Nerves of the Lungs.*

Galen, Vesalius, and others, conceived that there were very few nerves sent to the lungs, and that those which were, went only to the membranes, and not to the substance of the lungs. They believed also that the discharge of blood from the lungs and the existence of vomitæ without pain, while there was great pain in peripneumony, was a confirmation of this opinion. Fallopius corrected this idea, and showed that the bronchiæ were also attended through their course with nerves. There often exists vomitæ and effusions of blood in the lungs; and Haller says, the lungs can be lanced without the animal feeling pain, but still the bronchiæ are extremely sensible.—Water accumulated in the interlobular cellular membrane, or the infarction of blood into it, gives no acute pain, but only a sense of weight and difficulty of breathing. It is an oppression in a great measure depending upon the return of the blood from the lungs unchanged in consequence of the compression of the cells.—The sensibility of the bronchiæ, and the existence of their nerves, appear in asthma; and also from the pain excited by calculi, and from their irritability excited by recent ulceration, or when vomitæ are discharged into them.

The connection betwixt the stomach and bronchiæ, through the medium of the par vagum and pulmonic plexus, is evident from those asthmatic attacks which depend upon sourness in the stomach.

Thus we see that the par vagum has a most appropriate name, and that it is nearly as extensive in its connections as the sympathetic itself. It is distributed "to the œsophagus, pharynx, and larynx; to the thyroid gland, vessels of the neck and heart, to the lungs, liver and spleen, stomach, duodenum, and sometimes to the diaphragm." The recollection of this distribution will explain to us many sympathies; for example, the hysterical affection of the throat when the stomach is distended with flatus, the exciting of vomiting by tickling the throat, the effect which vomiting has in diminishing the sense of suffocation, that state of the stomach which is found upon dissection to accompany hydrophobia, whether spontaneous, or from the bite of a dog.

OF THE ACCESSORY NERVE, OR THIRD DIVISION OF THE EIGHTH PAIR OF NERVES.

The spinal accessory nerve of Willis, is that which, taking its origin like the cervical nerves from the spinal marrow, ascends through the spine and foramen magnum of the occipital bone, and passes again from the scull like one of the nerves of the brain. It passes out with the par vagum, is attached to it in its passage, but again separates from it when it has escaped from the scull. Under the base of the cranium it is attached to the ninth pair also. Commonly this attachment is firm; sometimes, it is by a short filament. This parasitical nerve then passes behind the internal jugular vein, and passes obliquely downward and backward. It then perforates the mastoid muscle, and passes in a direction across the neck to the shoulder. While it pierces, it gives nerves to the mastoid muscle; and after piercing, it entangles its branches with those of the third and fourth cervical nerves. It then passes under the trapezius muscle, and is distributed to it, where it is on the back of the neck and shoulder. From the distribution of this nerve we discover that the shrug of the shoulders is very natural; and "*pourquoi les grandes passions de l'ame nous portent à gesticuler, pour ainsi dire, malgré nous!*"*

OF THE NINTH PAIR, OR LINGUALIS MEDIUS OR HYPOGLOSSUS.

After passing out from the scull by the anterior condyloid foramen, the ninth nerve adheres to the eighth pair, by cellular filaments and the interchange of nerves. It receives also

* Sabbatier.

branches from the first cervical nerve, or from the branch of union of the first and second cervical nerves. When dissecting in the neck, we find the ninth nerve lying by the side of the internal jugular vein under the styloid muscles, and coming out from under the occipital branch of the internal carotid artery.

The nerve here divides, or it may rather be said to give off that branch which is called the *DESCENDENS NONI*. The continued trunk of the nerve passes before the external carotid artery and forwards under the larger branches of veins in a direction tending towards the *os hyoides*. Here it turns upwards under the *stylo-hyoideus* and *digastricus* muscles, and betwixt the *stylo-glossus* and *hyo-glossus*. Where the nerve is near the *os hyoides*, and passing under the *stylo-glossus* muscle, it sends down a twig which passes to the fore part of the throat, and chiefly to the *sterno-hyoideus* and *thyro-hyoideus*.

The continued nerve is distributed to the muscles of the tongue and lower jaw, and glands under the jaw; and it terminates by numerous filaments, which form a net-work amongst the muscles of the tongue; to which is united part of that branch of the fifth pair which goes to the tongue.*

The *RAMUS DESCENDENS NONI* passes downward, and obliquely over the trunk of the carotid artery, and under the thyroid vein. In the superficial dissection of the muscles of the neck, two slender twigs of nerves will be seen to come from the side of the neck, and crossing the jugular vein, unite to this descending branch. Those twigs come from the second and third cervical nerves; † and a little ganglion or plexus is formed by their union with the *descendens noni*. From this centre are sent out many delicate and superficial nerves to the *omo-hyoideus* and *sterno-thyroideus* muscles.

Thus we find that the ninth nerve has connections with the eighth pair of nerves, with the spinal accessory, the sympathetic, the cervical, and phrenic nerves. When this nerve is injured, the motion of the tongue is lost, but the sense of taste remains unimpaired. On the contrary, when the branch of the fifth nerve going to the tongue is hurt, the sense of taste is lost, while the mobility of the tongue remains. ‡ Columbus knew a man who had no sense of taste, and who eat indifferently every thing presented to him. When he died, Columbus was curious to know the cause of this; and he found

* This has been called *plexus cerato-basio-stylo-glossus*!

† In some instances those twigs are found to be derived from the first origin of the phrenic nerve.

‡ Soemmerring de *Cerebro & Nervis*.

That he altogether wanted the gustatory nerve or lingual branch of the inferior maxillary nerve. Cases detailed by Professor Scarpa still further illustrate this fact. A woman, subject to epileptic attacks in an early age, was seized in her pregnancy with an hemiplegia and loss of speech. From this attack, by the use of medicines, she recovered; but in a future labour the disease recurred. Now the cure was less complete; for, though she regained the use of her arms, she never recovered the faculty of speech, or was only capable of articulating with great dissonance the monosyllables, affirming or denying. Upon making her exert herself to speak, they observed no motion in the tongue; and, upon applying the hand under the jaw, they could feel no motion in the muscles of the tongue; yet she relished her food and drink, and had an acute sense of taste, and could swallow easily. He mentions another case, where the patient was attacked with a sense of weight at the root of the tongue, a difficulty of speaking, and copious flow of saliva. In a short time he entirely lost the power of articulating, but retained acutely the sense of taste.*

From the extensive connection of this nerve, particularly with the eighth and sympathetic nerves, we see why tremors of the tongue and aphonia may be occasioned by hysteria, hypochondriasis, colics, or worms in the intestines.†

OF THE CERVICAL NERVES.

FIRST CERVICAL NERVE. TENTH PAIR OF THE SCULL.
SUBOCCIPITAL NERVE. This is the least of all the nerves of the spine; it arises by two roots from the medulla spinalis. Some difference has been observed in the manner in which those roots collect their filaments; and only the anterior root or fasciculus is described by some authors. The posterior fasciculus is indeed the larger, and comes in a direction different from the general direction of the roots of the other cervical nerves. The roots of the suboccipital nerve are connected with the spinal accessory nerve, but seldom form a ganglion with it; and frequently they form a union with the posterior roots of the second cervical nerve. The fibres of the suboccipital nerve passing transversely and a little obliquely upwards, go out under the vertebral artery, and betwixt it and the first vertebra of the neck. The little trunk of the suboccipital nerve, thus formed, and having escaped from the

* Tabulæ Neurologicæ, Auctore Anton. Scarpa.

† J. F. Will. Bachmer Comment. de 9no pare Nervorum

spine, rises for a little way upwards, swells into a kind of ganglion, and then divides into two branches.

The anterior of these branches is the smaller. It passes down upon the inside of the vertebral artery; its filaments unite with the hypoglossal nerve, or ninth pair, and with the superior cervical ganglion of the sympathetic and with the first branch of the second cervical nerve.* The larger and posterior branch divides into eight twigs, which are chiefly distributed to the muscles moving the head—to the oblique superior and inferior, the recti postici and laterales, complexus, and splenius. Some of those muscular branches unite with that branch of the second cervical nerve which ascends upon the occiput.

SECOND CERVICAL NERVE. This nerve, arising by a double origin from the spinal marrow, like the other nerves of the spine, passes betwixt the first and second vertebræ. It is larger than the last; and after forming a little ganglion by the side of the transverse process of the first vertebra, divides into two branches.

The **SUPERIOR BRANCH** sends up a considerable division behind the projection of the transverse process of the first vertebra, to unite to the suboccipital or first cervical nerve. Several twigs pass forward to unite with the superior cervical ganglion of the sympathetic nerve, and with some of the more anterior branches of the third cervical nerve, and with the ninth and spinal accessory nerves. Besides these intricate connections, irregular branches of this nerve proceed to the small muscles, moving the head and lying on the fore part of the spine. The *posterior* branch of the second pair of cervical nerves is chiefly a muscular nerve. It rises up by the side of the complexus, gives branches to that muscle and to the splenius, and communicates with the branches of the first cervical. Its branches are also distributed to the upper part of the trapezius muscle, from which they extend along the integuments, covering the occiput even to the summit of the head.

The **THIRD CERVICAL NERVE**, in the first place, communicates with the second and fourth cervical nerves, with the sympathetic and lingual nerves, and sometimes sends down a twig to unite with the origin of the phrenic nerve from the fourth cervical nerve.

From the anterior division of the third cervical nerve, branches pass to the splenius and complexus, and trapezius, and upwards to the ear. We may observe also a cutaneous

* A very small nerve is described by some authors as passing from the anterior division of the nerve, into the canal of the vertebral artery.

nerve which accompanies the external jugular vein, viz. *NERVUS SUPERFICIALIS COLLI*; the distribution of which is chiefly to the angle and margin of the lower jaw, while some of its branches enter the parotid gland, and unite with the extremities of the portio dura and other facial nerves.

The SMALL POSTERIOR DIVISION of the nerve passes to the complexus, spinalis cervicis, and multifidus spinæ, while at the same time it unites to the branches of the second cervical nerve.

The FOURTH CERVICAL NERVE, coming out from betwixt the third and fourth cervical vertebræ, divides into its anterior and posterior branches like the other cervical nerves.

The first goes to form, with the third and fifth cervical nerves, the *PHRENIC NERVE*. It sends also a branch to the sympathetic, to the integuments of the neck and shoulder, and to the supra and infra spinatus muscles. These are called by *Soemmerring SUPERCLAVICULARES INTERIORES, MEDII, and POSTERIORES*.

The great POSTERIOR DIVISION of the fourth cervical nerve, passes to the muscles of the spine and shoulder, in conjunction with the branches of the third cervical nerve.

FIFTH CERVICAL NERVE.—This nerve comes of course from betwixt the fourth and fifth vertebræ, and from betwixt the *scaleni* muscles. It divides also into two branches. The SUPERIOR of these passes backwards to the muscles of the back and shoulder, and a branch formed by it; and the sixth passes down under the scapula and serratus major. This superior division of the nerve sends up also two small twigs of communication with the fourth cervical nerve.

The INFERIOR DIVISION of the nerve sends down upon the side of the neck a considerable branch to the formation of the phrenic nerve. It communicates with the root of the sixth nerve, and sends muscular branches backward.

The SIXTH CERVICAL NERVE.—The muscular branches of this nerve are large and extensive in their course. They pass into the levator scapulæ, extend under the trapezius, and unite with the extreme branches of the spinal accessory nerve. They are prolonged to the latissimus dorsi and serratus magnus.—Branches also extend down behind the clavicle, and under the pectoral muscle.

Besides these branches, this nerve communicates with the fifth, and gives out an origin to the phrenic nerve; and lastly, uniting to the seventh, it passes into the axillary plexus.

The SEVENTH CERVICAL NERVE.—This nerve goes almost entirely to form the axillary plexus. There is a communicating nerve from the last to this, and from that communicating branch

generally there passes off a filament to the phrenic nerve; and from the very root of the nerve there passes off a branch to the lower cervical ganglion of the sympathetic. Irregular twigs also descend from this nerve under the clavicle to the pectoralis minor and major.

The EIGHTH CERVICAL NERVE.—The greater part of this nerve passes to the axillary plexus. It sends small branches to the lower cervical ganglion of the sympathetic, and to the muscles of the breast; which last descend behind the clavicle.

RECAPITULATION OF THE DISTRIBUTION OF THE CERVICAL NERVES.

UPON reviewing the description of these nerves, we find that the general tendency of their branches is backwards over the side of the neck, to the muscles moving the head and shoulders. We find also that they are connected in a very intricate manner with the most important nerves of the cranium. High in the neck and under the jaw, they are connected with the portio dura, with the fifth pair, with the eighth and ninth pairs, and with the sympathetic. Towards the middle of the neck they are still throwing their connecting branches to the descendens noni, and sympathetic, and eighth pair. The lower cervical nerves again are still supporting their connections with the lower ganglion of the sympathetic.

Further, we find the phrenic nerve derived (most frequently) from the third and fourth, and branch of communication betwixt the fourth and fifth. The AXILLARY PLEXUS is formed by the fifth, sixth, seventh, and eighth cervical nerves, and first of the back.

OF THE DORSAL NERVES.

THERE are twelve dorsal nerves. These, as we have described, are formed by two fasciculi of fibres; one from the fore, and the other from the back part of the spinal marrow. These filaments run for some way superficially in the length of the spinal marrow before they pierce the dura mater. They pierce it separately; the posterior branch first forms a ganglion, and then the two fasciculi are united. They are now betwixt the heads of the ribs. We must here recollect, that the trunk of the sympathetic nerve, which passes along the cavity of the thorax, runs down behind the pleura, and passes before the heads of the ribs through all the length of the back. It receives, as it passes the interstices of the several ribs, at each interval, a

communicating nerve from the spinal marrow ; a branch from the intercostal or dorsal nerves.

Those communications are sent in the following manner : the proper dorsal, or intercostal nerve, sends its greater branch forwards betwixt the ribs ; some lesser branches pierce backwards to the muscles of the back : opposite to this there goes out from each nerve the first branch of union with the sympathetic, and this union forms a firm ganglion. Sometimes there run out in this direction two short branches from the spinal nerve, to unite with the ganglion of the sympathetic ; but more commonly there passes in a retrograde direction from the intercostal nerve, where it is about to take its course between the ribs, another branch of communication which joins the sympathetic. Sometimes the dorsal or intercostal nerves send off three communicating branches to the sympathetic.

The intercostal nerves pass on betwixt the ribs, in company with the intercostal arteries, and reach even to the sternum.—In this course they supply the intercostal muscles and triangularis sterni, while they are at the same time sending out branches, which, piercing the intercostal muscles and fascia of the thorax, are distributed to the muscles on the outside of the chest.—Those branches which we mentioned as passing betwixt the heads of the ribs, and which are sent off immediately upon the trunk escaping from the vertebral opening, supply the multifidus spinæ and levatores costarum, and other extensor muscles of the spine. Slips proceeding from the second, third, fourth, and fifth intercostal nerves, send branches to the pectoral muscles, the serratus anticus, and serratus posticus superior, trapezius, and rhomboides. The sixth, and all the lower nerves of the back, send branches from betwixt the ribs to the latissimus dorsi, serratus inferior, and abdominal muscles. The eleventh and twelfth are distributed to the diaphragm, quadratus lumborum, psoas magnus, and iliacus internus.

LUMBAR NERVES.

THE lumbar nerves are five in number. The first comes out under the first lumbar vertebra, and the others in succession. Their trunks are covered by the psoas magnus. They pass very obliquely downward, and the three lowest are of remarkable size.

In the general distribution, we may first remark the posterior branches, which go backwards to the muscles which support and extend the spine. Again, the anterior branches ; which give, 1st, additional branches to the sympathetic nerve

as it passes over the vertebræ of the loins, and by which it is supported and reinforced till it terminates in the pelvis ; 2dly, they have frequent connection with each other, and with the last nerve of the back, and first of the sacrum ; 3dly, they send out branches, delicate but of great extent, to the muscles of the loins and back, and to the abdominal muscles and integuments of the groin and scrotum ; 4thly, the principal anterior branches of the lumbæ nerves pass down to form (along with the great nerves of the sacrum) the anterior crural nerve, the obturator, and the great ischiatic nerve.

SACRAL NERVES.

THE nerves which come out from the extremity of the medulla spinalis, or cauda equina, through the sacrum, are in general five in number. Sometimes there is one more or less. The first division of each sacral nerve is into those branches which pass out by the posterior foramina of the sacrum, and those which, by the anterior foramina, come into the pelvis.—The posterior branches are very small, and pass to the muscles supporting the spine ; while the anterior ones are particularly large, especially the first and second, which, with the lowest of the loins, go to form the largest nerve of the body, the ischiatic nerve.

It is difficult to recollect the distribution of the several branches of the lumbar and sacral nerves, when taken thus together ; but when we deliver the description of the nerves of the thigh and leg, we count them, and hold them in remembrance with comparative ease. At present we are best prepared to follow the sympathetic nerve in its course.

OF THE GREAT SYMPATHETIC NERVE, OR INTERCOSTAL NERVE.

NOTWITHSTANDING the idea of this nerve which I have endeavoured to convey, I conceive that we must still continue to speak of the origins of this nerve in the usual way, for the sake of simplicity and arrangement.

The sympathetic nerve is in general considered as originally derived from the sixth pair ; or, we may say, it takes its origin from the sixth, where it passes by the side of the carotid artery, and from the vidian branch of the fifth pair. It appears without the scull, sometimes behind and sometimes before the carotid artery, and sometimes it is double in its exit from the base of the scull. Almost immediately after it has escaped from the scull, it forms its first ganglion ; which is ve-

ly large and remarkable, and has the name of the SUPERIOR CERVICAL GANGLION of the sympathetic nerve. It is of a soft consistence and reddish colour, and it extends from the scull to the transverse process of the third vertebra. It gradually tapers downwards until it terminates in the slender nerve, which in the neck is extremely small. This ganglion has much variety of shape in different subjects, and may be said in general to receive twigs of nerves upon the back part; it gives them out upon the fore part.

The superior cervical ganglion of the sympathetic nerve receives nerves from the second, third, and fourth cervical nerves, and even sometimes from the root of the phrenic nerve. It has also connections with the hypo-glossal, par vagum, and glosso-pharyngeal nerves. It sends out branches to unite with the glosso-pharyngeal, and which follow that nerve in its distribution to the tongue and pharynx. Many of its branches surrounding the carotid artery form connections with the internal and external laryngeal nerves, and proceed in meshes, or form plexus along with the branches of the artery. These may be followed to great minuteness.

To be more particular in the description of these anterior branches of the sympathetic nerve, they are called the NERVI MOLLES, or NERVI VASORUM. They are nerves peculiarly soft, with a greater proportion of cellular membrane; they spread in net-works along the arteries, and form frequent connections by little knots like small ganglions. Classed with these nervi vasorum, are branches which pass forward from the upper ganglion of the sympathetic, to unite with filaments from the internal laryngeal nerve of the par vagum, and which form the external laryngeal nerve. It is remarked, that none of these branches of the sympathetic nerve are distributed to the larynx and pharynx without being mingled and associated with the glosso-pharyngeal nerve, or with the pharyngeal branch of the par vagum.* Of the nervi molles, some form a plexus upon the internal carotid artery. These are extremely soft and pulpy, and are united with branches which descend from the glosso-pharyngeal nerve. A net-work is also formed, which covers the beginning of the external carotid artery.—From this, as from a centre, branches are sent out with the arteries to the neck, and face, and glands under the jaw; and these last, with a mesh which passes up upon the temporal artery, unite with the portio dura of the seventh pair.

It has been often observed, that the branches of the carotid artery have a peculiar provision of nerves, and that these nerves

* Scarpa.

are more numerous and minutely distributed than in any other part of the body. There are indeed no nerves in any part of the body which have so extensive and intricate connections with important nerves as the cutaneous nerves of the face and neck. This distribution of the nerves is, I conceive, a provision for that power possessed by the imagination, or rather that uncontrollable connection which exists betwixt the feelings and the action of the vessels in blushing.

The lowest of the *nervi vasorum* or *molles*, sent off from the superior ganglion of the sympathetic nerve, descends in the course of the trunk of the nerve, and forms, with other branches, the superior cardiac.

This nerve, generally called *NERVUS CORDIS SUPERFICIALIS*, passing down in the direction of the trunk of the sympathetic nerve, and near the *longus colli* muscle, is for some length a very slender branch; but in its course it receives two, three, or four additional twigs from the sympathetic, and branches which come under the carotid artery from the pharyngeal nerves, or *nervi molles*. When this superior cardiac nerve is within an inch or two of the subclavian artery, branches of union pass betwixt it and the recurrent nerve of the *par vagum*; and branches of the nerves passing to the heart from the lower cervical ganglion, also join it. It then, attaching itself to the investing membranes and sheaths of carotid and subclavian arteries, forms with others a plexus of nerves, which run along the great vessels to the heart.

The continued trunk of the sympathetic, where it emerges from the superior cervical ganglion, is extremely small. It descends behind the carotid artery, and lies near to the spine. When opposite to the fifth and sixth cervical vertebræ, the inferior cervical ganglion of the sympathetic is formed.—In this course, twigs of communication pass betwixt it and the cervical nerves, or join it with the beginning of the phrenic nerve.

But not unfrequently there are three cervical ganglions formed by the sympathetic nerve; the superior, middle, and inferior ganglions: or it happens that we find the sympathetic nerve split into two branches in the neck; one of which forms the middle, and the other the lower ganglion.

There are received by the *MIDDLE CERVICAL GANGLION*, or, *THYROID GANGLION*, branches of nerves from the third, fourth, fifth, and sixth cervical nerves, and also sometimes from the phrenic nerve. The ganglion is by no means constantly found, and it is irregular in its size and shape. When large, and in what may be considered as its more perfect state, it gives off some considerable branches. Of these, part unite with the su-

perior cardiac nerve already mentioned ; others form the great or deep cardiac nerve, while lesser ones play round the subclavian artery, and unite with the lower cervical ganglion, or the the upper thoracic ganglion.

The deeper cardiac branch of the sympathetic, splitting and again uniting so as to form rings, runs outwards, attached to the arteria innominata and arch of the aorta, to the heart. In this course, while it passes before the trachea, it forms connections with the recurrent branch and trunk of the par vagum. Under the arch of the aorta, we find this branch concentrated to form the *GANGLION CARDIACUM* of Wrisberg, or *GANGLION MOLLE* and *PELLUCIDUM* of Scarpa. This ganglion is like a mere enlargement or swelling of the nerve. From this, four or five branches may be enumerated ; 1st, a branch passing behind the pulmonary artery to the back of the heart, and following the left coronary artery ; 2dly, a small division to the anterior pulmonary plexus of the par vagum ; 3dly, a pretty considerable branch which, passing behind the aorta, and betwixt it and the pulmonary artery, is distributed with the right coronary artery to the anterior part of the heart. On the left side of the neck, the sympathetic, receiving on the one side branches from the cervical nerves, and on the other giving off branches, which descend behind the carotid artery to the heart, (*viz.* the superior cardiac) often splits before it forms the middle or thyroid ganglion, and sometimes throws its branches over the thyroid artery, and the ganglion lies upon that artery. Again, from the ganglion there descend two series of numerous lesser filaments, which form meshes upon the thyroid and subclavian arteries to the heart. Others proceed downward behind the arteries to the lower cervical ganglion. Those branches which descend upon the arteries, intangle the roots of the thyroid, transversalis cervicis, and internal mammary arteries, in their plexus ; these uniting, follow the subclavian artery, and form again a plexus upon the arch of the aorta. This is joined by branches from the par vagum and recurrent. The principal branches of this plexus terminate in the cardiac ganglion under the arch of the aorta.*

The *LOWER CERVICAL GANGLION*† of the sympathetic nerve is placed upon the limits betwixt the neck and thorax upon the head of the first rib, and by the side of the musculus longus colli ; and it is in part covered by the root of the vertebral artery. The ganglion is of an irregular cushion-like shape. It

* This description of the sympathetic nerve on the left side follows the more usual distribution, but is not peculiar to the left side.

† The lower cervical or cardiac ganglion of the sympathetic nerve.

lies close to the cervical nerves which go to the brachial plexus, and it receives branches from them.* Branches also pass from this ganglion to the par vagum and recurrent, and also pass on to the cardiac and pulmonic plexus. That nerve, which must be considered as the continued sympathetic, throws a ring round the root of the vertebral artery, and sending out branches upon the subclavian, terminates in the first dorsal or thoracic ganglion.

THE SUPERIOR THORACIC GANGLION.

THIS ganglion surpasses the other thoracic ganglions in size. It is, indeed, frequently composed of many branches of the nerve in the neck, coming both before and behind the subclavian artery. It receives also nerves from the three or four lowest cervical nerves, and first dorsal nerve. It is of a very irregular figure, or rather it varies exceedingly in its shape; so that by various anatomists it is described as round, oval, triangular, quadrangular, cylindrical!—Filaments proceed from this ganglion into the canal of the vertebral artery, and to the cellular coat of the subclavian artery, and to the cardiac plexus, and also to the pulmonic plexus; or to supply the posterior surface of the lungs.

SYMPATHETIC NERVE IN THE THORAX.

THE sympathetic nerve, (as we have explained in describing the dorsal nerves,) through all its course in the thorax, has additional branches from the dorsal or intercostal nerves. It forms also, while it is lying on the side of the vertebræ, a division in the thorax, which it will be important to recollect. This nerve is sent more forwards upon the body of the vertebræ, and passes into the abdomen betwixt the crura of the diaphragm; while the trunk of the sympathetic continues its course by the heads of the ribs, passes under the ligamentum arcuatum, and downwards upon the lumbar vertebræ.

The SPLANCHNIC NERVE, then is this anterior branch of the sympathetic in the thorax. It is the great nerve of the viscera of the abdomen. It generally has two or four roots from the trunk of the sympathetic nerve, where it is opposite to the sixth, seventh, and eighth intercostal nerves. It is seen lying under the pleura, and passing obliquely over the bodies of the

* And even it receives sometimes from the fifth and sixth, more rarely the seventh and eighth, from the first and second of the back; and lastly, from the phrenic nerve.—Sometimes these connections are wanting.

lumbar vertebræ, from the seventh to the tenth. It then passes betwixt the crura of the diaphragm, enters the abdomen, and forms the great semilunar ganglion.

One or more branches are sent forward from the sympathetic, commonly from the ganglions, opposite to the interstice betwixt the ninth and tenth, or tenth and eleventh ribs.—These also pass the diaphragm, and unite with the semilunar ganglion. There is, however, a considerable variety to be observed both in the origins of the splanchnic nerve, and in the number of these subsidiary branches. A larger branch, going off betwixt the tenth and eleventh ribs, is so common, that it has the name of *SPLANCHNICUS MINOR*, OR, *ACCESSORIUS*. This nerve as frequently terminates in the renal plexus, as in the semilunar ganglion; or sometimes it sends branches to both.

CÆLIAC GANGLION AND PLEXUS.

THE ganglion which is called the semilunar ganglion, has no regular shape—and least of all when it is fully dissected. It is formed by the splanchnic nerve, and by branches which come from the lumbar nerves. It lies by the side of the cæliac artery, and consists of many lesser ganglions, (sometimes to the number of eleven or twelve,) matted together into a glandular-like shape.

The semilunar ganglions of the splanchnic nerves lying on each side of the root of the cæliac artery, their connection with each other is frequent and intricate; so that they throw a mesh of nerves round the root and branches of this artery, which is the great source of vessels to the stomach, liver, and spleen.—This plexus, formed by the semilunar ganglions round the cæliac artery, is the solar or cæliac plexus.

CÆLIAC PLEXUS.

THE cæliac plexus is the great source of nerves to the higher viscera of the abdomen. The splanchnic nerves are the great, but not the only nerves which form this plexus. The par vagum sends branches down from the stomach which join it; and even the phrenic nerve, which is the nerve of the diaphragm, sends down twigs to unite to the branches of the splanchnic and par vagum. We shall find also small nerves which come from the seat of the kidney, and which are derived from the superior lumbar nerves. These pass across the crura of the diaphragm, and enter into the cæliac plexus. In pursuing the nerves of the viscera further, we have it no

longer in our power to follow individual branches, but have rather to mark the course, and enumerate the various sources of the plexus, and net-work of nerves which follow the great vessels.

From the cæliac plexus, there pass out, 1. Nerves which accompany the phrenic arteries upon the lower surface of the diaphragm. 2. Nerves to the liver:—and of these there are two plexus, the right and left hepatic plexus; one passes along the vena portæ, biliary ducts, and right hepatic artery, to the right side of the liver, the gall-bladder and ducts; this of course is the RIGHT HEPATIC PLEXUS: the LEFT HEPATIC PLEXUS passes along the left hepatic artery; and this has connection with the cardiac nerves, branches of the par vagum. 3. That plexus, which runs upon the lesser curve of the stomach, while it is formed in a great measure by the par vagum, has also connection with the solar or cæliac plexus. 4. The plexus of nerves which pass to the lower orifice of the stomach and duodenum is chiefly a division of the right hepatic plexus. These nerves, to the liver, stomach, and duodenum, are attached to the branches of the cæliac artery. Along the great splenic artery, which is also derived from the cæliac artery, there passes out a plexus of nerves to the spleen. From this splenic plexus there pass nerves to the great omentum; and they even unite with those passing out upon the duodenum, and which attach themselves to the right epyptic artery, and take a course upon the great curvature of the stomach.

Thus the solar or cæliac plexus is a great central net-work of nerves, which pass out in divisions to the liver, spleen, pancreas, stomach, duodenum, and omentum.

SUPERIOR MESENTERIC PLEXUS.

THE place and connections of the superior mesenteric plexus is at once known, when it is considered that it is formed upon the root of the superior mesenteric artery.—It is formed by the cæliac plexus being continued down upon the aorta so as to involve the root of the mesenteric artery, and by nerves coming over the side of the vertebræ of the loins from the lumbar nerves. This plexus spreads betwixt the lamina of the mesentery, and extends upon the branches of the artery, and of course is distributed to the small intestines and part of the colon. It consequently supplies the mesenteric glands, and sends nerves also to the pancreas, that join those which it receives from the splenic plexus.

INFERIOR MESENTERIC PLEXUS.

THE same mesh of nerves, being continued down upon the face of the aorta, surround the lower mesenteric artery, and follow its branches. This is the lower mesenteric plexus, or mesocolic plexus; and it is formed in a great measure from the branches of the continued trunk of the sympathetic nerve. As this plexus spreads upon the branches of the lower mesenteric artery, it passes to the left side of the *intestinum colon* and *rectum*—while the lower mesenteric plexus is continued from the upper one. On the side of the lumbar vertebræ it is continuous with the renal and spermatic plexus; and towards the pelvis, with the hypogastric plexus.

Before considering the other lesser plexus of nerves in the abdomen, it is necessary to follow the continued trunk of the sympathetic nerve which we had described as following closely the lateral part of the dorsal and lumbar vertebræ, whilst the splanchnic nerves pass obliquely over them to the viscera of the upper part of the belly.

THE CONTINUED TRUNK of the SYMPATHETIC NERVE, after it has given off the splanchnic nerve in the thorax, sends several small nerves forward over the vertebræ to the mediastinum and sheath of the aorta. It then passes the diaphragm, keeping close to the transverse process of the vertebræ. When, however, it comes lower upon the lumbar vertebræ, it lies more upon the side of their bodies, and the connections with the lumbar nerves are by small and numerous twigs which stretch over the side of the vertebræ. In this course, it is giving off upon the fore part numerous irregular twigs to the several plexus. Where it lies under the vessels which pass to the kidney, it sends up some branches to the renal plexus.

The renal plexus, however, is not entirely formed of these branches of the continued sympathetic, but is rather a continuation from the cæliac and superior mesenteric plexus; while the lesser splanchnic nerve, which was sent off in the thorax, also terminates in it. This plexus is thrown over the vessels of the kidney, and forms several little ganglions.

From the renal plexus descends the SPERMATIC PLEXUS.—This plexus of nerves in woman follows the spermatic artery in its distribution to the ovaria and uterus.

In passing down upon the loins, the sympathetic nerve forms five or six ganglions with the branches from the lumbar nerves. These are oblong, angular, stellated—irregular in their form, as in their number, situation, size, or the twigs which, in their union with the sympathetic, form them. Betwixt these gan-

glions or connections with the lumbar nerves, the sympathetic is not always one nerve, but is sometimes split into several smaller nerves, which unite again. From the sympathetic nerves of either side we have to observe frequent interchange of branches, which sometimes attach themselves to the lumbar nerves, sometimes creep under the aorta, or unite to the plexus covering the face of the aorta.—There are several little ganglions formed by these nerves upon the face of the lumbar vertebræ: they have the name of ganglia accessoria.

Before the sympathetic nerve descends into the pelvis, it has become extremely delicate. In many subjects it seems to terminate in the last lumbar, or first sacral nerve; but, upon more minute dissection, lesser branches will be found to descend amongst the loose cellular substance of the pelvis.—When regular, or perhaps we may say with truth when regularly and fully dissected, the sympathetic nerves of each side are seen to descend upon the fore part of the sacrum, and form connections with the sacral nerves similar to those with the dorsal nerves.—As they descend, they of course approach, and finally unite in an acute point on the os coxigis.—At the points of union of these extreme branches of the sympathetic nerves with the branches of the sacral nerves, small ganglions are formed; and there pass out branches from them, which cover the intermediate surface of the sacrum with an extensive plexus. The ultimate ganglion, formed by the union of the two sympathetic nerves, is the *coxygeal ganglion*, and from it there pass three or four nerves to the extremity of the rectum.

HYPOGASTRIC PLEXUS.

THIS is a plexus which lies on the side of the pelvis, and involves the hypogastric artery. It consists of the nerves passing to the parts contained in the pelvis; which do not, however, pass in distinct branches, but, like those of the abdomen, are formed into minute interwoven network. The hypogastric plexus takes no determinate origin, but is continuous with, or formed by, the extreme branches of the sympathetic nerves, the extremity of the spermatic plexus, the sacral nerves, (and particularly the third sacral nerve,) and by the branches of the accessory ganglions on the sacrum.

OF THE PHRENIC NERVE.

THE phrenic or diaphragmatic nerve arises from the cervical nerves, passes obliquely down the neck, enters the thorax, and is distributed to the diaphragm.—This nerve has much va-

riety in its derivation. It comes chiefly from the third cervical nerve, deriving also some twigs from the fourth and second. But sometimes it takes an origin very high in the neck, from the par vagum or ninth nerve; and even the superior cervical ganglion of the sympathetic is described by some as furnishing a root.—Lower in the neck it will be found in some subjects to derive very small additional twigs from the fifth or sixth cervical nerves, or lower ganglion of the sympathetic.

The phrenic nerve, thus formed, descends into the thorax betwixt the subclavian artery and vein. In the chest it proceeds downward and forward, attached to the mediastinum and before the root of the lungs.* It takes its course upon the outside of the pericardium, and from the pericardium slips off to the surface of the diaphragm. From the position of the heart, the left phrenic nerve differs a little in its course from the right; and it passes over the pericardium, covering the apex of the heart. The phrenic nerve of the right side, besides supplying the diaphragm, sends down through the diaphragm (to the right side of the vena cava) the ramus anastamoticus.—This communicates with the semilunar ganglion of the sympathetic, or with the division of the solar or cæliac plexus which passes along the phrenic arteries. From the phrenic artery of the left side, there pass down with the œsophagus small nerves which, appearing in the abdomen, unite with the cæliac ganglion, or some of its divisions; and both phrenic nerves will be found by some minute branches to unite to the par vagum.

These however, are but minute branches. The great destination of the phrenic nerve is to the diaphragm. The branches strike out from the diaphragm like roots from a centre; they pass some way only covered by the pleura, and then pierce into the substance of the muscle. There are innumerable experiments upon living animals, which shew the connection of this nerve with the action of the diaphragm. When the nerve is stimulated, the diaphragm is excited to contraction; when cut, pressed, or tied, it becomes relaxed and inactive, and there is difficulty of respiration; when the spinal marrow is injured

* Ludwig, Martin, in the Edinburgh Essays, and others explain the action of the diaphragm upon the supposition of the mechanical pressure of the lungs upon the phrenic nerve. It is a piece of doctrine inconsistent with knowledge of the general laws of the œconomy. It is repugnant to comparative anatomy, and it is evident that the soft and elastic distention of the lungs could not compress the firm nerve. Moreover, the lungs when distended do not press upon the mediastinum, for it is the dilation of the thorax which causes the lungs to inhale the atmospheric air. See *Wrisberg de Neruo Phrenico*. Sandif. Thef. vol. ii. p. 260. It is betwixt the heart and muscles of respiration that the strict relation and sympathy exist—When in turning the child in utero, and when the cord has been pressed, I have felt the strong convulsive *fetches* of the muscles of respiration endeavouring, by the play of the lungs, to compensate for the loss of the placenta.

low in the vertebræ of the neck, or in the vertebræ of the back, the external muscles of respiration cease to act, but the diaphragm still continues its function; and in this case, as observed by Mr. Hunter, the patient lives for some days, breathing by the diaphragm. If the phrenic nerves be divided in a living animal, the diaphragm ceases to act, and the abdominal muscles lose their opponent muscles, and remain as in expiration; but still the respiration is continued by the motion of the ribs. If after this the spine be divided, the motion of the lungs ceases entirely, and the animal dies suddenly.—The injury of the spinal marrow above the origin of the phrenic nerves, is of course suddenly fatal, because it destroys at once the function of the diaphragm, and muscles moving the chest. From the connection of the phrenic nerve with the par vagum, we may explain the sympathy betwixt the trachea and the diaphragm, how the irritation of the trachea occasions coughing and the convulsive action of the diaphragm; in the same manner in the affection of the stomach, singultus, from the sudden action of the diaphragm and abdominal muscles, (which usually alternate in their action,) may be explained. Again, a connection of nerves might be followed from the origins of the phrenic to the sympathetic nerve, and branches of the fifth pair to the nose: which accounts for that sympathy of action which occasions sneezing from irritation of the membrane of the nose.

NERVES OF THE ARM; AXILLARY, OR BRACHIAL PLEXUS.

THE nerves which proceed from the spine, and go to supply the arm, are formed into an intricate plexus before they divide into the several nerves of the arm.

This brachial or axillary plexus, is formed of five of the spinal nerves; viz. the fifth, sixth, seventh, and eighth cervical nerves,* and the first dorsal nerve. The highest of these nerves proceed from betwixt the fourth and fifth cervical vertebræ; the last from betwixt the first and second dorsal vertebræ. They pass out betwixt the middle and anterior division of the scaleni; and even while covered by these muscles, and before they have proceeded far from their foramina, the last nerve of the neck and first of the back unite†.—The plexus is continued from above the clavicle to the edge of the tendon of the latissimus dorsi. It allows of no natural division. The

* This is of course counting the suboccipital as the first cervical nerve.

† Before the nerves which form the plexus intermix their filaments, or are connected together, they send off small branches to the scalenic muscles, to the muscles of the spine, and to the levator scapulae. The branches which they give to the sympathetic nerve, we have already noticed.

axillary nerve passes for some way close under it, and then perforates betwixt the divisions which form the radial nerve.

From the axillary plexus proceed these nerves :

1. The thoracic nerves.
2. The supra and infra scapular nerves.
3. The circumflex, or articular nerve.
4. The perforans casserii, or external cutaneous nerve.
5. The radial nerve.
6. The ulnar nerve.
7. The muscular spiral nerve.
8. The internal cutaneous nerves.

1. The **THORACIC NERVES**. Although the nerves which supply the muscles of the chest are derived from the intercostal nerves, as we have seen, yet there also pass off branches from the axillary plexus to the great and little pectoral muscles, to the latissimus dorsi, to the skin and mamma. These thoracic branches proceed from the upper division of the plexus, or that which gives out the external cutaneous, and one of the roots of the radial nerve.

2. The **SUPRASCAPULAR NERVE** comes off from the upper edge of the plexus, and is the highest of the branches. It runs towards the root of the coracoid process, it passes through the notch of the scapula, and goes to supply the supra and infra spinatus muscles, the teres minor, and the subscapularis.

The **SUBSCAPULAR NERVES** come out from the posterior part of the plexus along with the articular nerve. They are attached to the subscapular muscle, they turn round the fleshy edge of the muscle, and insinuate their branches betwixt the tendon of the latissimus dorsi and the teres major.

3. The **CIRCUMFLEX, OR ARTICULAR NERVE, OR AXILLARIS**, lies very deep. It comes from the back part of the plexus, passes behind the neck of the humerus, and above the tendon of the latissimus dorsi, and teres major. One of its branches we trace into the teres major, while another passes round the bone, and is distributed to the under surface of the deltoid muscle, the joint, and the cellular membrane.

4. **PERFORANS CASSERII, OR THE EXTERNAL CUTANEUS NERVE**. This nerve passes through the coraco-brachialis muscle before the os humeri, to gain the outside of the arm. From its perforating this muscle, and being described by Casserius, it is called the nervus perforans Casserii. Before passing through the coraco-brachialis muscle, it sends down a

branch of communication with the radial nerve ; and in many subjects it will be found to be like a branch from one of the origins of the radial nerve. Where the nervus perforans lies betwixt the brachieus internus muscle and biceps (and, of course, after it has perforated the coraco-brachialis muscle,) a branch or two are sent up to the heads of the biceps muscle ; another branch turns inward to the belly of that muscle ; and, finally, twigs pass inward to the cellular membrane, which involves the brachial artery.

The continued nerve passes obliquely across the arm, and under the biceps. When approaching the outside of the arm, it divides into three small branches ; one to the integuments which are upon the supinator longus, another to the integuments on the inside of the fore-arm, and a third, which continues its course along the edge of the supinator longus to the wrist. Of this prolonged branch of the perforans Casserii, a minute twig is lost on the ligament of the wrist, another passes to the ball of the thumb, and a third goes round to the integuments of the back of the thumb.

5. The RADIAL NERVE. This nerve is formed by those divisions of the plexus which surround the brachial artery, and sometimes by a division of the perforans Casserii. It takes its course by the side of the brachial artery, and gives off 10 branches until it has sunk under the aponeurotic expansion of the biceps muscle.

When the radial nerve has come to the bend of the arm, it gives off three branches. The first belongs to the pronator teres, flexor radialis, and palmaris longus, and flexor digitorum ; a second passes to the pronator teres ; and a third to the deep muscles of the fore-arm, and to the flexors of the thumb particularly, and also to the pronator quadratus muscle. The radial nerve, continuing its course down the fore-arm betwixt the flexor sublimis and profundus digitorum, sends off other branches to those muscles. Before passing under the ligament of the wrist, it gives out a branch which emerges from the tendons, and passes to the integuments, short flexor, and abductor muscles of the thumb.

The trunk of the radial nerve passes with the tendons of the flexor muscles of the fingers under the ligament of the wrist. In the palm of the hand it divides into five branches ; the first passes to the abductor and flexor pollicis brevis ; a second goes to the adductor pollicis, and side of the thumb next the fore-finger ; the third passes to the fore-finger, and to the lumbricalis muscle ; the fourth to the side of the fore and middle fingers ; and the fifth to the sides of the middle and

little finger. All these nerves, while in the palm of the hand, send off branches to the lumbricales muscles.

6. The ULNAR NERVE comes off from the lower part of the plexus in union with the internal cutaneous nerve. It descends upon the inside of the arm, and is tied down by the fascia, and then passes behind the internal condyle of the humerus.—While above the bend of the arm, it gives off a superficial branch to the integuments on the inside of the arm, and the ulnar side of the fore-arm; at the same time it sends a muscular branch through the triceps muscle, along with the arteria profunda inferior. Immediately above the elbow joint, twigs are sent off, some of which accompany the ramus anastomoticus major of the brachial artery. After passing the condyle of the humerus, it sends a branch to the flexor carpi ulnaris, and to the head of the flexor digitorum profundus. It then sinks deeper betwixt the flexor ulnaris and flexor digitorum sublimis; it is here connected with the ulnar artery, and descends along with it to the wrist. In this course, along the fore-arm, the ulnar nerve gives branches to the flexor digitorum sublimis. Often it sends a branch of communication to the radial nerve, while some few lesser muscular nerves are sent off, and accompany the branches of the ulnar artery.

When arrived near the wrist, the ulnar nerve divides into two branches. The continued trunk passes on under the protection of the tendon of the flexor ulnaris, and then under the annular ligament into the palm of the hand; while the branch takes a turn under the flexor ulnaris, and over the edge of the flexor digitorum profundus. It passes then over the lower end of the ulna to the back of the hand. On the back of the hand it is found branching over the expanded tendons and under the veins, and is finally distributed to the back of the little and ring fingers. This is the *ramus posticus*.

The continued ulnar nerve passes under the palmaris brevis muscle and palmar aponeurosis, and above the flexor brevis and adductor minimi digiti. Here it divides into two, (the sublimis and profundus of Camper,) and these again into four principal branches—to the integuments on the ulnar edge of the hand, and adductor minimi digiti—to the outer edge of the little finger,—to the side of the little and ring fingers, and a branch which communicates with the radial nerve.

Albinus, Monro and Camper differ in regard to the distribution of nerves to the lumbricales muscles, which only proves that the twigs passing to those little muscles are irregular.—They come chiefly from the deep branch of the ulnar nerve, whilst others are from the radial nerve.

7. The MUSCULAR SPIRAL NERVE. We find the external

cutaneous nerve, or perforans casserii, passing before the arm-bone. The muscular spiral nerve passes behind the bone, and takes a spiral turn under it to get to the outside of the arm. It perforates the flesh of the arm betwixt the middle and the short head of the triceps muscle. Before it perforates the triceps muscles, the muscular spiral sends off branches which pass over the tendon of the latissimus dorsi; and before it enters the triceps muscle, it may be observed to divide into several branches. Three of these may be mentioned: a branch to the middle head, and one to the short head of the triceps muscle, and a third and larger nerve which pierces betwixt the muscles, along with the trunk of the nerve.

This last nerve does not follow the trunk of the nerve in its course, but perforating the triceps more directly across, it comes out behind the supinator longus, where it takes its origin from the os humeri. This is a cutaneous branch, and might be considered as the external cutaneous nerve with as much propriety as the perforans casserii. Often we shall find some lesser branches of the muscular spiral nerve piercing the fibres of the triceps muscle, and terminating in the skin.

The great cutaneous division of the nerve, after piercing the triceps muscle, takes its course along the integuments covering the supinator longus muscle; and here it sends a branch in upon the bend of the arm, and on the edge of the triceps muscle. It then descends upon the outside of the fore-arm, and divides into three principal branches, and then again into innumerable cutaneous twigs, and is continued down over the back of the thumb and hand.

But the great division of the muscular spiral nerve comes out betwixt the head of the supinator longus muscle and the bone, and is deep seated. This branch then lies betwixt the supinator longus, and brachieus internus; and here it gives off several small twigs to the muscles. Continuing its course by the side of the supinator longus and flexor radialis, it divides into a deep and superficial branch. The superficial branch passes down on the side of the tendon of the supinator longus, and near the wrist it becomes quite superficial, and is distributed to the integuments of the back of the hand.

8. The INTERNAL CUTANEOUS NERVES. Of those we may describe three:—

1. The *great internal cutaneous nerve*. This nerve is derived from the ulnaris at its root, or comes off from the plexus along with it, passes down the arm, giving off no considerable branches, accompanies the basilic vein and twists its branches over it, divides into four branches upon the fascia of the fore-arm, and running betwixt the fascia and veins of the

fore-arm, it is finally distributed to the cellular membrane and integuments, while one of its branches reaches to the ligaments of the wrist.

2. The *cutaneous nerve of Wrisberg* comes sometimes from the axillary plexus, as a distinct nerve; sometimes it is a branch of the great internal cutaneous nerve; sometimes it is derived, or a nerve which takes its place is derived from the intercostal nerves. This nerve of Wrisberg is distributed to the integuments of the arm, and terminates near the internal condyle.

3. The *upper and internal cutaneous nerve* comes from the first intercostal nerve, or from the second, and passes out betwixt the first and second ribs. It supplies the integuments of the arm, and the glands and fat of the axilla.*

There are besides several nerves derived from the intercostal nerves, which cross the axilla, and supply the arm-pit and side.

NERVES OF THE THIGH, LEG, AND FOOT.

IN tracing the nerves of the lower extremity, we find no difficulty in the arrangement at least, for they fall into a very simple and natural order. They are all derived from the lumbar and sacral nerves. The great nerves are three in number. One passes out under Poupart's ligament to the extensor muscles of the leg, *viz.* those which lie on the fore part of the thigh. This of course is called the anterior crural nerve. The second nerve is the obturator nerve, so called because it passes out from the pelvis by the thyroid hole. This nerve lies amongst the deep muscles of the thigh, and distributes its branches chiefly to the adductor muscles. The third nerve is the greatest nerve of the body, *viz.* the ischiatic nerve. It passes out from the back part of the pelvis, through the sacro-sciatic notch, and takes its course down the back of the thigh into the ham. In this course it supplies the muscles lying on the back of the thigh, but its chief destination is to the leg and foot.

OF THE CUTANEOUS NERVES OF THE THIGH.

IT will be found considerably to take from the intricacy of the minute anatomy of the nerves of the lower extremity, to dispose first of these nerves which lie under the integuments of the thigh.

* See System of Dissections, vol. ii. plate 1. g.

These cutaneous nerves of the thigh come from the lumbar nerves, or more immediately from the anterior crural nerve.— They pierce the tendon of the oblique muscle of the abdomen, or pass under Poupert's ligament, and are distributed to the groin, scrotum, and betwixt the fascia and integuments of the fore part of the thigh. There may be described five cutaneous nerves on the fore part of the thigh, *viz.* the *external cutaneous*, the *middle cutaneous*, the *anterior cutaneous*, the *internal cutaneous*, and those of the groin and scrotum.

The **EXTERNAL CUTANEOUS NERVE** is that which comes out from the belly near the superior spinous process of the ilium. It divides almost immediately into two great branches, and in the front view of the thigh the anterior branch alone is to be seen. It takes a course above the fascia in the direction of the line which divides the vastus externus from the rectus femoris, and terminates near the knee, while the posterior branch passes over the tensor vaginæ femoris, and down upon the outside and back of the thigh. It is derived from the third lumbar nerve.

The **MIDDLE CUTANEOUS NERVE** rises from amongst the integuments of the groin, and emerges from under the fascia near the upper edge of the sartorius muscle. It passes down upon the rectus muscle, and is distributed to the integuments in three or four divisions.

The **ANTERIOR CUTANEOUS NERVE** comes out to the integuments very high up, and in the middle of the groin betwixt the pubes and tuberosity of the os ilii. It passes down the thigh along the surfaces of the sartorius and vastus internus muscles. This, like all the other cutaneous nerves, runs along above the fascia, and on the lower surface of the skin.

The **INTERNAL CUTANEOUS NERVE** is the least regular. It does not pierce the fascia in one trunk, but sends three, four, or five branches through the fascia, which are distributed to the integuments on the inside of the thigh. Some of these, after running a considerable way under the fascia, emerge and encircle the inside of the knee.

Besides these more remarkable cutaneous nerves, there come down small nerves to the groin and scrotum. The first lumbar nerve sends down the external spermatic nerve. This joining the spermatic plexus, helps to supply the cord and testicle; and in women the same nerve goes to the womb within the pelvis, and following the round ligament, terminates on the fat of the pubes and groin. A branch from the second lumbar nerve passes also to the glands and fat of the groin, the pubes, and cremaster muscle. This branch is remarkable for

the circuitous course it takes round the ilium and inside of the ligament of the thigh.

ANTERIOR CRURAL NERVE.*

THIS nerve arises from the union of the second, third, and fourth of the lumbar nerves, or the second and third lumbar nerves uniting into one trunk, are afterwards joined by a division of the fourth, † or the anterior crural, is formed by the anterior branch of the third and the first branch of the second lumbar nerve, ‡ or by the four first lumbar nerves; and the anterior crural nerve, at its origin, lies under the psoas magnus, and, as it descends, it holds its course between the psoas magnus and iliacus internus. It then descends towards the thigh, and passes out under Poupart's ligament; and in its course along the brim of the pelvis, it is for some way covered by the external iliac artery. Here, while within the pelvis, it gives off several small nerves, which pass into the iliacus internus, and under the psoas magnus muscles. These form a kind of small plexus.

As the anterior crural nerve passes under Poupart's ligament, it splits into its numerous branches which supply the muscles and integuments on the fore part of the thigh. From the fore part of the nerve there is sent out a musculo-cutaneous branch, which, while it descends and supplies several of the muscles of the thigh, gives out the middle cutaneous nerve. The anterior cutaneous nerve is sent off lower down, but almost immediately after it has passed under Poupart's ligament. The internal cutaneous nerve is sent off from some of those branches which run under the internal articular artery.

The last of the cutaneous branches of the anterior crural nerve, and the most important, is the *NERVUS SAPHENUS*, or *CUTANEUS LONGUS*. This is the chief cutaneous nerve of the leg; but it is to be distinguished as a particular nerve, so high as under the external articular or circumflex artery, being a division of what is called the *NERVUS LONGUS*. This nerve is sometimes joined by a branch of the obturator nerve; and the muscular branches which it gives off, pass into the vastus internus.

When we are dissecting in the course of the femoral artery, we have to observe two nerves running parallel to, and connected with the sheath of the artery. That which is on the inside is the largest, the course of which we shall prosecute. It

* *Crural nerve, truncus lumborum, femoralis magnus.*

† Fischer—Walter.

‡ Sabbatier and Haller.

follows the artery through the tendon of the triceps muscle, but it does not descend into the ham with the popliteal artery. It comes out again through the tendon with the perforating branches of the popliteal artery, or with the upper and internal articular artery. It then becomes a superficial nerve, and descends upon the inside of the leg with the saphena vein, to the inner angle and foot.

Those two nerves, which are so closely connected with the femoral artery in the middle of the thigh, are very often taken up with the extremity of the artery in amputation. This occasions twitching in the stump and a fetid discharge.

Where the continued nerve descends upon the inside of the leg, it sends out many twigs to the integuments, and is entangled with the saphena vein. Here it has been pricked in bleeding in the ankle.—Sabbatier gives us an instance of this. The patient had been previously subject to nervous affections. She felt in the instant of the operation an acute pain, which was succeeded by convulsive motions, first of the limb and then of the whole body. These attacks returned from time to time, she lost her health, and for many years was still in suffering almost continual.—He relates to us another instance of the injury of this nerve accompanying the saphena vein, in the case of a young man who received a wound with the small sword in the inside of the knee. There came on much fever and swelling of the part, with great pain of the limb. This subsiding, there followed slight trembling of the limb, which gradually increased to an extreme degree. The caustic was proposed, but the patient had not resolution to let it be applied. After long suffering with exhausted strength, he was at last relieved by nature, and his health gradually returned.

These branches we have mentioned are only the cutaneous or superficial branches of the anterior crural. The larger and more numerous set of branches are those to the muscles lying on the fore part of the thigh. These diverge suddenly into innumerable twigs, and are entangled with the branches of the arteries, and follow them in their distribution. There can be no excuse for bestowing particular names on these branches; to say that one is the branch to the pectinalis, another the branch to the sartorius, another to the rectus, &c. is sufficient.

OBTURATOR NERVE.

THIS nerve arises by fasciculi from the second and third lumbar nerves, and sometimes by a small twig from the fourth. It is formed, however, chiefly by the third lumbar nerve. It then lies under the internal border of the psoas magnus. It

descends into the pelvis, and goes obliquely downwards to pass through the ligamentous membrane which fills up the thyroid hole. The obturator nerve, before it escapes from the pelvis, sends off a branch which, accompanying the parent nerve, is given to the external obturator muscle. When it has escaped from the pelvis, this nerve lies before the heads of the triceps, and behind the pectinalis muscle; and it here divides into two branches in the very middle and internal flesh of the thigh. The anterior of these branches passes down betwixt the adductor muscles, or heads of the triceps, supplies those muscles and the gracilis, and sends a branch of communication with the saphenus nerve. The posterior division goes down betwixt the adductor magnus and brevis, sends branches to the obturator externus and adductor brevis, and continues its course downwards before the great fleshy partition of the adductor muscles, and parallel with the crural vessels, to the fat above the inner condyle of the femur.

THE ORIGIN OF THE ISCHIATIC NERVE.

THE ischiatic nerve is formed by the two last nerves of the loins, and the three first of the sacrum: or we may describe its origin more particularly thus; the anterior branch of the fourth lumbar nerve and the trunk of the fifth uniting, form a strong cord of about two inches in length; this root is joined to another nearly as large, formed by the first and second sacral nerves; and again, a third division joins it from the inferior branch of the second sacral nerve and from the third.* The ischiatic nerve is thus formed of three great roots matted together into a kind of plexus, and then passes betwixt the pyriformis muscle and the gemini, and thus escapes from the back part of the pelvis by the great ischiatic notch.

But before following this great nerve into the thigh, we must take notice of many lesser nerves sent out from the sacral nerves, and from the trunk of the ischiatic nerve. These nerves pass to the muscles and integuments of the nates and back of the thigh to the perineum and private parts.

OF THE LESSER NERVES WHICH GO OUT FROM THE BACK PART OF THE PELVIS.

1st. THERE pass off branches from the second and third lumbar nerves, which form a muscular nerve of considerable

* This third and lowest origin, before uniting with the others to form the ischiatic nerve, gives out many small branches to the hypogastric plexus and viscera of the pelvis, to the perineum and private parts.

size. This muscular nerve passes down upon the inside of the pelvis, escapes from the back part of the pelvis, and is distributed to the gluteus medius, the gluteus minimus, and the tensor vaginae femoris.

2d. There pass off one or two very small nerves from the body of the ischiatic nerve, while yet within the pelvis, or from the middle divisions of its origins, which go to the pyriformis and gluteus medius muscles.

3d. Just where the great nerve passes over the posterior ligaments of the pelvis, there goes off a twig to the obturator externus, gemini and quadratus femoris. While these nerves are sent off upon the anterior face of the nerve, there goes backward a large fasciculus of nerves to the glutei muscles, and to the integuments of the nates.*

There proceeds a nerve somewhat more important than these from the third sacral nerve, *viz.* the NERVUS PUDENDUS. This nerve passes out above the short sacro-ischiatic ligament, and re-enters under the long sacro-ischiatic ligament. It then runs by the side of the ramus ischii, and ascends in the perineum and branches to the erector penis, accelerator urinæ, and transversalis perinei, and passes on to the integuments and external parts of generation.

OF THE CUTANEOUS NERVES OF THE BACK OF THE THIGH.

WHEN the integuments are dissected off from the nates and back of the thigh, we see two sources of the cutaneous nerves; first from the lumbar nerves, which give out many small nerves which pass over the spine of the os ilii, and the branches of the anterior and outer cutaneous nerve; and secondly, from under the lower margin of the great gluteus muscle, there come many extensive cutaneous nerves. These are derived from the nervus cutaneus posterior et superior, and branches of the ischiatic nerve, in this manner; *

Just as the great ischiatic nerve has escaped from the pelvis, it is joined by the SUPERIOR and POSTERIOR CUTANEOUS NERVE; or, rather, a small twig is sent off from the great nerve to join this cutaneous nerve† on its emerging from the pelvis. It divides into several branches, and it is one of these

* Branches of that root of the ischiatic nerve which is derived from the third sacral nerve, go also out to the buttock; and some describe a superior, middle, and inferior cutaneous nerve of the nates.

† The posterior cutaneous nerve rises in general from the trunk of the ischiatic nerve, within the pelvis, and is joined by a branch from the third sacral nerve.—Joerd. Haafe.

which may be seen superficial and above the delicate fascia, running down upon the outer hamstring muscles, to the back of the knee-joint. Another branch piercing the fascia separately, comes down upon the integuments covering the outer and back part of the thigh, and terminates on the outside of the knee. A little further down, the ischiatic nerve gives off small nerves to the muscles surrounding the hip-joint; and, whilst the sciatic nerve is passing over the quadratus femoris, the INFERIOR and INTERNAL CUTANEOUS NERVE is given off. This nerve runs down even to the inside of the calf of the leg. The EXTERNAL and POSTERIOR CUTANEOUS NERVE is a branch sent off from the ischiatic nerve, after it has descended from under the gluteus maximus, and just before its division into two fasciculi, *viz.* the tibial and peroneal nerves. This external and posterior cutaneous nerve passes down upon the integuments of the back part and outside of the leg.

OF THE TRUNK OF THE ISCHIATIC NERVE IN THE THIGH.

BUT we must not allow these lesser branches to distract our attention from the general course of the great nerve, which passes over the gemini muscles, betwixt the tuberosity of the ischium and the trochanter major, then runs deep under the bellies of the hamstring muscles, and is lodged immediately in the great cavity behind the knee-joint, in company with the popliteal artery and vein. In this course the sacro-sciatic gives off branches to the quadratus femoris, the biceps cruris, semitendinosus, and semimembranosus and triceps.

A little below the middle of the thigh, the great ischiatic nerve divides into the internal and greater, and the lesser and external popliteal nerves. But as this is really the division into the two great nerves of the leg, we take the more determinate names of tibial and fibular nerves.

TIBIAL NERVE.

THE greater and more internal of these divisions of the popliteal nerve, is the tibial nerve. Whilst it is yet in the hollow behind the joint formed by the hamstring tendons, it gives off a nerve which comes out from the ham, and descends superficially on the back of the leg. This has been called RAMUS COMMUNICANS TIBIAL. When this nerve has arrived opposite to the beginning of the tendon achillis, it turns a little to the outer side, passing upon the outer margin of the achilles tendon, over the outer side of the heel-bone, and is finally distri-

buted on the outside and fore-part of the foot. Upon the back of the leg, this nerve unites with a branch descending from the fibular nerve, nearly in the same course, and with the same destination.

After giving off this superficial branch, the tibial nerve sends branches to the back of the knee-joint and popliteus muscle, to the plantaris muscle, and to both heads of the gastrocnemius. It then descends behind the articulation, and behind the head of the tibia. It then passes under the origins of the soleus, and betwixt the soleus and flexor longus digitorum pedis, and tibialis posticus, and descends to the inner angle. In this course it furnishes many branches to the lower part of the popliteal muscle, to the tibialis posticus, to the flexor communis digitorum, and to the flexor pollicis longus, and many of these branches, and in cutaneous twigs. We have also to observe a particular branch which the tibial nerve detaches, which passes betwixt the heads of the tibia and fibula, and goes to supply the muscles arising from the fore part of the interosseous ligament. Further down, two or more small branches of the nerve also perforate the interosseous ligament, to supply the muscles lying on the outside of the tibia. The tibial nerve, in its course amongst those posterior muscles, accompanies the posterior tibial artery. When it has arrived behind the inner ankle, it sends off a branch to the integuments of the inside of the foot, and to the abductor muscle of the great toe. Continuing its course by the side of the heel-bone and under the ligament, it begins to split into those branches which are naturally called the plantar nerves, because of their lying in the sole of the foot.

THE PLANTAR NERVES.

THE internal plantar nerve passes over the abductor muscle of the great toe, and by the inside of the short flexor to the first metacarpal bone; and in this course it gives out several twigs to the muscles of the sole of the foot. It now divides into three branches. These are distributed to the great toe, to the second, the third, and one side of the fourth toes; and these nerves in their course give branches to the lumbricales and interossei muscles.

The external plantar nerve is the lesser of the two. It gives branches to the short flexor and adductor of the little toe, and to the massa carnea Jacobi Silvii. It gives also a deep branch to the third and fourth interosseous muscle and adductor muscle of the great toe. Another of its branches makes the arch with the internal plantar nerve, while its extreme distribution is to the little toe, and to one side of the fourth toe. These

nerves of the sole of the foot are connected with the internal and external plantar arteries, and are protected like them by the plantar aponeurosis.

THE FIBULAR NERVE.

THE fibular nerve is the more external division of the popliteal nerve. It separates from the tibial branch about four inches above the knee-joint; it does not pass down under the gastrocnemius, like the tibial nerve, but turns towards the outside of the joint, and passes round the head of the fibula, and under the origin of the peroneus longus.—Before the fibular nerve passes from behind the joint, it gives off several branches. There are sent down two branches to the integuments. One of these branches unites with the *communicans tibiei*, and descends with it to the outer ankle. Sometimes this anastomosis is formed high in the leg upon the heads of the gastrocnemius. More generally there is a double communication formed by these nerves about the termination of the belly of the gastrocnemius muscle in the achilles tendon. This prolonged branch of the fibular nerve terminates upon the side and upper part of the foot, and upon the little toe. There are also some nerves sent off from the fibular, which are distributed about the back and sides of the knee-joint.

When the fibular nerve has turned over the head of the fibula, it divides into two great branches. The DEEPER SEATED OF THESE BRANCHES, though it is not the largest of them, may be considered as the continued trunk. It passes deep amongst the muscles, lying betwixt the tibia and fibula, and supplies the *tibialis anticus*, the *extensor communis digitorum*, *extensor longus pollicis*, and the *peroneus brevis*. Thus the deeper division of the fibular nerve, taking its course between the *tibialis anticus*, and the *peroneus longus* muscles, and lower down betwixt the tibia and *extensor pollicis longus*, continues giving off branches in rapid succession, and when it arrives at the annular ligament, it is much diminished. Here it divides into the *ramus dorsalis pedis profundus* and *superficialis*.—This division is made after the nerve has crossed under the tendon of the *tibialis anticus* muscle, and, while it lies betwixt the lower heads of the tibia and fibula.—Although they are distinguished by the name of deep and superficial branches, they are both deep compared with the extremities of the great and outer division of the peroneal nerve. The branch which lies most towards the outside of the foot, passes under the *extensor digitorum brevis* muscle, and on the outside of the tarsus. It distributes its branches to the *extensor digitorum brevis*, and

interossei muscles. That branch which is more towards the inside of the foot, although distinguished by the term superficialis, goes forward not only under the fascia which covers the foot, but also under the tendons; and after dividing and again uniting, and after sending off some small branches, it comes out betwixt the great toe and the second toe, and sends numerous branches to their contiguous surfaces.

THE GREAT SUPERFICIAL DIVISION of the FIBULAR NERVE is sometimes double, or immediately splits into two. Its first branches are to the peroneus tertius, extensor longus digitorum, and to the peroneus brevis and secundus. The trunk or principal division runs down under the head of the peroneus longus, and then coming out from under it, continues its course beneath the strong aponeurosis, which covers the muscles on the fore part of the leg. It then pierces the aponeurosis and becomes cutaneous, and runs obliquely down to the convexity of the foot, giving off in its course a nerve which passes over the outer angle.

THE METATARSAL NERVES.

WHEN the superficial branch of the peroneal nerve descends before the ankle-joint, it divides into the metatarsal nerves, or the rami dorsales pedis. The EXTERNAL of those branches passes above the tendons, and above the tendinous expansion on the dorsum pedis; is united to the extreme branches of the ramus communicans tibiei, and is finally distributed to the outside of the third toe, to the fourth, and to the inside of the little toe.—The INTERNAL branch is again subdivided; one branch extends over the middle of the foot to the second and third toes, while the other passes straight along the metatarsal bone of the great toe (above the tendons;) sends many branches over the inside of the foot, and terminates on the inside and dorsum of the great toe.

END OF THE FIRST PART.

INTRODUCTION.



OF THE SENSES.



THE Senses are those faculties by which the active principle within us has communication with the material objects by which we are surrounded. Through them, we receive those simple sensations which are the first elements of our thoughts, and the means of developing all the powers of the understanding. The exercise of our senses, however, is familiar to us from so early a period, that we never think of attending to their first simple intimations: before we are capable of reflecting on the nature of the perceptions which the several senses convey, they are so complicated and distorted by habits, association, and abstraction, that observation comes too late for us to ascertain the simple progress of nature. Philosophy may indeed revive the natural feelings of wonder at the spectacle of the universe; but often, instead of humble and cautious investigation, we follow the dictates of a creative imagination, and run into error and delusion in studying the operations of nature.

To the man, however, who looks upon nature with the calm and chastened delight which is the character of true philosophy, there is a conviction, that such researches may be carried too far. Wherever he directs his attention, whether to the structure of the human body, the physiology of vegetables, or the phænomena of chemical science; whether he endeavours to comprehend the system of the universe, or pores over the minutiaë of natural history, he finds every where a limit placed to his enquiries; a line which no industry or ingenuity can enable him to pass. We may please ourselves with conjecture beyond this limit, but we find that all our opinions on these subjects are merely a dream of something allied to the impressions of our gross senses. The agency of

the senses, the intercourse betwixt mind and matter, and the influence of the will over the body, are mysterious, and, probably, inexplicable phenomena ; yet we scruple not to explain them precisely and mechanically ; we reduce them to the level of our own capacity in the same manner as we fabricate to ourselves the idea of a Deity by the combination of all human perfections. When we imagine that we have discovered the secret of these mysteries, it is mortifying to find ourselves without any sign or language by which to communicate those great truths to the companions of our studies : we struggle for expression ; and, as all our ideas upon such abstract subjects are derived from analogy, we express our opinions respecting the powers of the mind, or the manner in which we perceive the objects of the senses, in the same language, and by reference to the same notions, which belong to the sensations themselves. From this scantiness and inaccuracy of language, it unavoidably happens, that very different ideas of the operation of the senses are expressed by several men in the same terms ; and in attempting to convey our ideas in language more precise and definite, we are insensibly led to materialize the faculties of the mind, and to make the operations of the senses merely mechanical. What other explanation can we give of theories, which suppose the nerves to be tubes carrying animal spirits, or containing an elastic ether ; or which represent them as vibrating cords, and reduce all the variety of sensation to the difference of tension and tone ? These are, indeed, what Dr. Reid calls them, “ unhandy engines for carrying images.”

Nothing has been undertaken in philosophy but entire systems, fathoming at once the greatest depths of nature. The custom has been to frame hardy conjectures ; and if upon comparing them with things there appeared some agreement, however remote, to hold that as fully sufficient. What chimeras and monstrous opinions this method of philosophising has brought forth, it would be more invidious than difficult to specify.

Bacon and Newton laid down the principles of philosophising on this basis, that on no account are conjectures to be indulged concerning the powers and laws of nature, but we are to make it our endeavour, with all diligence, to search out by experiment the real and true laws by which the constitution of things is regulated. In the subject now before us, we have a very remarkable proof of the superiority of investigation by experiment over the lazy indulgence of conjecture ; and I hope the whole tenor of the following account of the senses will strengthen the conviction of the student, that it is only by assiduous study, and patient observation of nature, that he is

to look for the attainment of knowledge in the medical profession.

The office of the brain and nerves is to receive the impressions of external bodies, by which corresponding changes and representations are made in the mind. We know nothing further than that, by the operation of the senses, new thoughts are excited in the mind. Betwixt the sensation excited in the organ of the external sense, and the idea excited in the brain, there is an indissoluble, though inexplicable, connection; the brain is not sensible, nor does the eye perceive, but both together give us the knowledge of outward things. But when the sensation is once received and communicated to the brain, it is treasured there, and may afterwards be excited independent of the external organ: hence comes the term *internal senses*.

INTERNAL SENSES.

Though I treat professedly of the external organs of the senses only, it may be necessary here, to say a few words on the internal senses. It appears that all sensations originate in the external senses or organs receiving the impressions of outward bodies: imagination is the power of combining these sensations, and memory the power of recalling them. These are powers of the mind, which, by the constitution of our nature, are gradually acquired, and increased by exercise. In infancy, the perceptions are simple and transitory; the memory is perfected by degrees, and with the store of ideas the imagination is invigorated.

It is in the combination and reciprocal effects of the mental powers and of the impression on the external senses, that we are to find an explanation of the operation of attention and its history. When the mental powers are led to the contemplation of an idea which assimilates easily with the sensation about to be presented by the external organ, the perception is quick, and the idea vivid; but when the mind is strongly impressed and occupied with the contemplation of past ideas, the present operation of the sense is neglected and overlooked. Thus, the vividness of the perception or idea, is always proportionate to the degree of undistracted attention which the mind is able to bestow on the object of sensation or of memory. In solitude and darkness, the strength of the memory in the contemplation of past events is increased, because there is no intrusion of the objects of the outward senses; and the deaf or blind receive some compensation for their loss in the increased powers which are acquired by a more frequent and undistur-

bed use of the senses which remain, and a keener attention to the sensations which they present. On the other hand, when we are under the enchantments of a waking dream or revery, our attention is wholly detached from the present objects of the senses ; and in this state we may even continue to read without understanding. This absence, in a certain degree, is common, natural, and by no means unpleasant ; it is the exertion of the faculty of the mind. But it may become disease ; for health consists in the due correspondence betwixt the excitement and the vigorous action of the body, and the operation of the mind when roused by the external senses.

The mind (united to the body) suffers in the diseases of the body. In the debility of the body, in fever, in spasms, and pain, the faculties of the mind languish, or are roused to unequal strength or morbid acuteness. Sometimes the phantasms and internal sensations of things once received by the outward senses, become so strong in the mind, as to be mistaken for objects actually present. Such phrenzy or delirium arises from a disordered and acutely sensible state of the internal senses.—These impressions being great in degree, hurry and bustle are in the countenance of the patient, and uncommon strength and violence in his actions ; as passion gives uncommon excitement to one in health, with a disregard or forgetfulness of all other things. In health, however vigorous the force of imagination may be, there is still a conviction that the ideas which it presents are not realities, and the operation of the external senses preponderates in recalling the attention to what exists around us. But when the internal perceptions become so strong as to be mistaken for realities, the effect is falsely attributed to the organs. It indeed sometimes happens, that this false perception is really owing to disease in the organ ; while it also occurs, that a too vivid perception of things absent proceeds from an affection of the brain, and not of the outward senses.

There is still another degree or class of diseased sensation, consisting in the modification of objects which are actually present to the senses. But this modification of things present (as when bodies actually at rest appear to be in motion) is not always occasioned by optical deception. Objects seem to turn round, and this we shall afterwards find to proceed from the insensible motion of the eyes ; but this motion of the eyes is occasioned by the disordered state of the internal sensation ; and the same feeling will be experienced if the eyes are shut.—For example, when we turn quickly round on our heel until we become giddy, it would appear that there is a disturbance of the usual order of sensation, and that the course of our im-

pressions is reversed; for while our sensations were formerly directed entirely by the impression made on the outward senses, the sensorial impressions now draw after them a sympathetic motion of the external organs.

This inverted communication betwixt the mind and organs is better exemplified in the organ of speech. Thoughts excited in the mind are represented by the signs of these ideas in speech. There occurs, however, not unfrequently, a diseased state of these operations of the internal senses, in which the ideas excited in the mind cannot be associated with their appropriate expressions; and although the patient has a distinct idea of what he means to express, he cannot recollect the words which belong to it; so that, when he asks for one thing, he names another which has no connection with it. Of this he is perfectly sensible, and yet he cannot correct himself.

There are more frequent instances of diseased corporeal sensation in hypochondriacs. In them, the sensation of pain and unusual feelings are falsely attributed to parts in which there is really no affection: for these feelings there is no apparent cause; they proceed from a disordered state of sensation in which the usual course of the impressions is altered, so as to occasion the patient falsely to attribute his suffering to sound and healthy parts. Thus, indigestion, the irritation of the bile, flatulency, colic, &c. often do not give the usual impressions, but the pains are attributed to outward parts. That there is sometimes an actual connection existing betwixt the external parts, to which these feelings are referred, and the internal organs, is evident from the fact, that pressure in the outward and sound parts has occasioned spasms in the internal organs. To such disordered transmission of the irritation of the internal parts we have to attribute the extravagant and ludicrous ideas which hypochondriacs entertain. In these people, there are diseases of parts, of the action of which, during their healthy state, (as I have already explained in the short introductory view of the nervous system,) we have no feeling nor consciousness, and over which the will has no power. But although in the healthy state of the œconomy there is no immediate route by which any sensation from these organs can be transmitted to excite a mental perception, it may happen, that, in their diseased state, when sensations do arise which forcibly attract the attention, there should be an obscurity in the feelings produced by their derangement, insomuch, that the mind may be deceived in regard to the direction of the sensation conveyed from them.

During health, there are vicissitudes of consciousness, sense, and voluntary motion, and of rest from voluntary exertion, in-

sensibility, and oblivion of the past. This is true, however, only comparatively, and by a gross reference to degree ; for even during natural sleep there is not a total oblivion of past perceptions, nor is there always a total unconsciousness of the present, as the senses are in part awake ; some one train of ideas is present to the mind ; and the lapse of time is observed. Even these perceptions are sometimes so strong as to be followed by voluntary exertion, and yet the patient remains asleep. Whatever conduces to take the excitement from the mind, or lessens the vivacity of its impressions, conduces to sleep.— Thus, rest, stillness, and darkness, by excluding the most lively impressions conveyed by the senses ; and hæmorrhagy and evacuations, by lessening the velocity of the circulation, induce sleep. Again, compression of the returning blood from the head, by giving it a slow languid motion, and by depriving the vessels of their freedom of action, also conduces to sleep ; because, as formerly remarked, the powers and faculties of the brain must be renovated through the means of the circulation.

By long watching and fatigue, the body is brought nearly to a feverish lowness. By sleep, rest is given to the voluntary muscles, and an abatement of the vital motions ensues ; the quiescent state of the muscles brings back the blood to the heart, with a slow, regular, and calm progression ; the heart is restored to its slow and equable pulsation ; the breathing becomes slower ; and the wasted strength of the system is recruited.

We may define sleep to be a state in which the sensations are dull, the voluntary muscles inert, and the vital motions calm and regular. In dreaming, the sensations are dull and obscure, but the imagination more alive and active ; unnatural sleep, or soporific diseases, may be characterized by the disordered imagination, and disturbed vital and voluntary motions. The vital actions, which are calm, slow, and equable, during natural sleep, become oppressed ; the sensibility, which is gradually diminished upon the approach of sleep, but always capable of being roused by the senses, becomes quite oppressed ; the voluntary muscles continue relaxed, as in sleep, or convulsed by irregular motions. In apoplectic diseases, the functions of the viscera proceed, and are but partially impeded ; but when the circulation of the blood and play of the lungs are obstructed, the operations of the mind are not equally unconcerned in the paroxysm ; for in syncope, the sudden depletion of the blood-vessels of the brain causes instant loss of sense and of voluntary motion.

If natural sleep is not profound, the imagination is awake ;

but there may be false perceptions, false judgment and associations, and disproportionate emotions ; and if sensations are perceived, they do not produce the ordinary associations.— If such a state of the intellectual functions occurs during the waking state, it becomes delirium. That this delirium is analogous to the perturbed state of the imagination during sleep, appears from the delirium in fevers uniformly showing its approach in the patient's slumbers only. It is a disposition to form false images and associations, which, in the beginning, the excitement of the outward senses has power to counteract, insomuch that a patient can be roused from delirium as he can be roused from sleep : but, bye and bye, the external senses lose their superiority, and their excitement is attended with unusual associations ; they no longer convey impressions to the intellect, but become subservient to and modified by it, and the judgment, which depends on the due balance of memory and imagination, is lost. In fever, the delirium is transitory ; in low fevers, it is combined with a comatose state. In melancholy, the delirium runs upon one object chiefly, or trains of ideas, which refer to the patient's health and corporeal feelings. In madness, the variety is infinite ; but chiefly consisting in a vitiated imagination and perverted judgment, with fierceness and increased power of corporeal exertion.

There are five organs peculiarly adapted to convey sensations to the mind ; and they may be considered as forming a medium of communication betwixt the external creation and the sentient principle within us ; they are at the same time the bond of union betwixt sentient beings. These organs are called the **EXTERNAL SENSES** ; viz. the sense of seeing, the sense of hearing, the sense of smelling, the sense of tasting, and the sense of touch. Individually, these organs convey little information to the mind ; but by comparison and combination, the simple and original affection or feelings of the mind are associated and combined to infinity, and administer to the memory and imagination, to taste, reasoning, and moral perception, the passions and affections, and every active power of the soul.

BOOK I.

OF THE EYE.



CHAP. I.

INTRODUCTORY VIEW OF THE PRINCIPLES OF OPTICS.

LIGHT is a matter thrown out from ignited, or reflected from shining, surfaces ; and which enters the eye and impresses that organ with the sensation of sight. The minuteness and inconceivable velocity of light, the facility with which it penetrates bodies of the greatest density and closest texture, without a change of its original properties, makes it the source of the most wonderful and astonishing phænomena in the physical world.

The smallest stream of light which propagates itself through a minute hole, is called a ray ; and, as rays of light pass through a uniform medium in a straight course, they are represented by mathematical lines. The sun is the greatest source of light, and perhaps the original and only source. But light is not uniform in respect of colour : every part of a ray is not capable of exciting the idea of whiteness which the whole raises. White light is composed of different kinds of rays, which individually give the sensation : one of red, another of orange, a third of yellow, a fourth of green, a fifth of light blue, a sixth of indigo, and a seventh of a violet or purple.* These are named the prismatic colours ; because, in the spectrum produced by making a ray of light to pass through a prism, these several colours are seen in the succession in which they are

* There is a fact not a little extraordinary regarding the emanation of rays from the sun, and which has been discovered in the present day, viz. that there are invisible rays, giving heat but no light, which are less refractible than the coloured rays ; and that all rays, in proportion to their refrangibility, have less power of producing heat. See Herschel on the invisible rays of light. *Phys. Trans.* 1800, part ii. p. 284.

above enumerated. Each of these rays individually impresses the eye with its own colour ; but when they all impress the eye at once, the sensation upon the organ of sight is a compound effect : no individual colour is presented, but that mixed light which is called whiteness, and which may be divided into its individual colours by passing it through a prism.

It is the nature of most bodies to absorb some of these rays of light and to reflect others from their surface ; consequently, the colours of bodies depend upon the particular rays which are reflected from them, or upon the combination of such rays as are reflected from them ; and a body appears of that colour of which the light coming from it is chiefly composed.

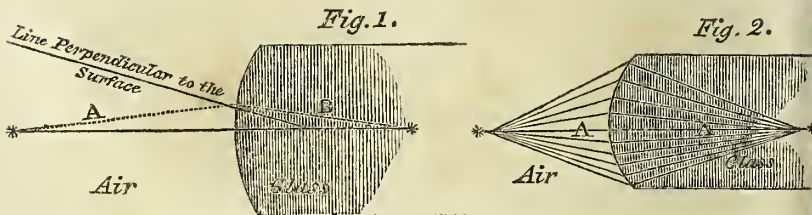
When a ray of light passes from a rarer to a denser medium, or from a denser into a rarer, it alters its course, if there be any obliquity in the original direction ; but if it strikes from one medium into another perpendicularly to the surfaces, its original direction is not changed. If the ray passing from the air enters obliquely into glass or water, or any denser medium, it turns more towards the perpendicular ; but if it passes through the glass and emerges again into the air, it resumes its original direction, diverging from the perpendicular. This effect of different mediums upon the ray of light, is called refraction : when a ray of light impinging upon a surface does not enter, it rises again to the angle of its incidence ; and this is reflection.

The prism is a piece of glass of a triangular form ; the inclined surfaces of which, when placed in the course of the ray of light, refract, and separate the several parts of the heterogeneous ray, and show its compound nature. If the sun be permitted to shine into a dark room through a small hole in the window-shutter, and the beam of light be made to fall upon a glass prism, it is, in passing through the glass, separated into its constituent parts ; because the several coloured rays have different degrees of refrangibility, in the order in which I have already enumerated them. If the rays, after passing through the prism, be made to pass also through a convex glass, they are brought again to a point in the focus of that glass ; and the effect of the whole colours thus re-united, is perfect whiteness. We might suspect that the beam of light were homogeneous, and that the degree of refraction gave different colours to the rays, were it not proved, that how much soever any of the coloured rays is further refracted, it does not change its nature : nor will rays suffer any change by reflection from bodies of different colours, for minium will appear yellow, green,

blue, &c. according to the colour of the ray of the light directed upon it.*

As the impression of light remains some time upon the nerve of the eye, it gave Sir Isaac Newton the opportunity of examining, whether each coloured ray makes a distinct impression upon the eye, or whether they so affect each other as to impress the sense of whiteness on the eye. When a burning coal is whirled in a circle, the eye perceives an entire circle of fire, because the impression made by the coal in any point of the circle remains until the coal returns again to the same place, and renews the sensation. When all the varieties of colours are painted in a circle, and turned in the same way with the burning coal, they must each make their separate impression upon the optic nerve; but the general sensation is whiteness; or when the teeth of a comb are drawn across the stream of light issuing from a prism, the different colours are intercepted in such quick succession, that a perfect whiteness is the result of the mixture of impressions. There are many experiments which show, that the inequalities of the refraction of light are not casual; that they do not depend upon any irregularity of the glass: on the contrary, it is proved, that every ray of the sun has its own peculiar degree of refractability, according to which, it is more or less refracted in passing through pellucid substances, and always in the same manner: and, lastly, that the rays are not split and multiplied by the prism.

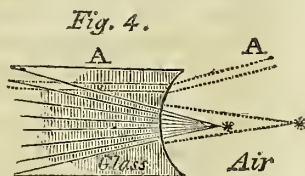
When a ray of light falls upon the surface of glass obliquely, it inclines to a line drawn (through the point of incidence) perpendicular to the surface.



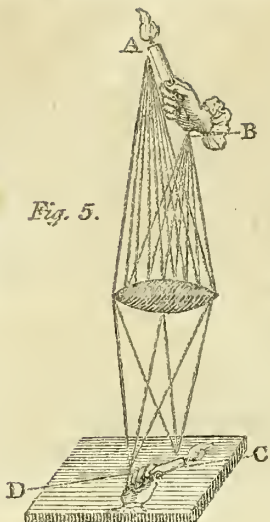
* It is found, that the coloured rays have not all the same power of illuminating objects; the orange ray possesses this property more than the red; the yellow more than the orange, &c.; and the maximum of illumination lies in the brightest yellow or palest green; nor do the several rays equally affect the thermometer. See Herschel's Exp. Trans. 1800, p. 2. p. 255.

Thus the ray *A*, fig. 1, proceeding from the object,* is refracted upon entering the mass of glass in the direction *B*, having a tendency towards the perpendicular line. By this means, if a number of rays proceeding from any one point, as in fig. 2., fall on a convex or spherical surface of glass, they will be inflected so as to gather about the perpendicular line *A* in the centre of the glass : which perpendicular line is the axis of the glass. If the rays of light proceeding from an object be made to strike into a mass of glass with a concave surface, the obliquity with which they impinge upon the surface, being the reverse of the convex surface, they are not made to converge upon the central line, but diverge from it.

Farther, the rays of the sun when passing from a medium of glass into the air, are turned, by refraction, farther off from the central line to which they were drawn in entering the convex surface of glass. But if the rays, in passing through the glass, were in a direction converging to the perpendicular line, they will be made to converge still farther, as is seen here in fig. 3.



If, however, the rays be made to pass from glass into the air, and the surface of the glass be concave as in fig. 4., the rays will be made to have a less degree of convergence, so as to remove the image * farther from the surface of the glass. But if the rays passing through the medium of glass have no convergence, but pass in parallel lines, they will diverge as the lines *A A*, fig. 4, do, when they emerge from the concave surface of the glass.



We see, then, the operation of a double convex glass, in forming the image of a luminous body upon a surface. If, foreexample, such a glass be held between a candle and a piece of white paper, (the distances being properly adjusted,) the image of the candle will appear very distinctly upon the opposed surface, but inverted; because the rays coming from the point A fig. 5., converge at c, and those from the point B at D.

Before proceeding farther in this short exposition of the principles of optics, it will be necessary to take a very slight view of the structure of the eye.

SIMPLE IDEA OF THE STRUCTURE OF THE EYE.

THE eye being that organ by which we are sensible to the rays of light, may be considered as consisting of two parts; that which receives the impression, viz. the retina or expanded nerve, and which is indeed the organ of the sense; and the tunics and humours, the apparatus by which the rays of light are made capable of forming an impression on the retina, or proper organ of the sense.

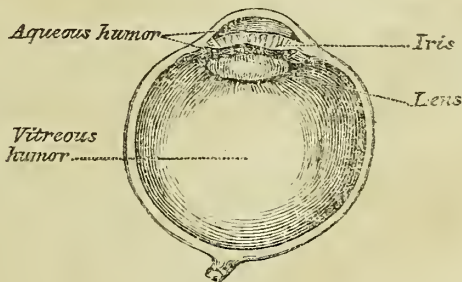
In an anatomical enquiry, it is chiefly the latter division of the subject which must occupy our attention; for, although we are necessarily led to consider the nature of the substance of the retina, the manner in which it is expanded, and supported by adhesion, and nourished by vessels, we must not venture far in the attempt to investigate the manner of its receiving or conveying the image of objects to the sensorium. We must turn to investigate the more useful subject of the structure, use, and diseases* of the humours and coats of the eye.

It is the first principle of the constitution of the eye, that the rays of light must be so concentrated as to impinge strongly on the expanded nerve or retina in the bottom of the eye. Now, as we have seen, that a lens (which is a double convex

* Of the diseases only as they relate to the explanation of the structure and economy of the eye.

glass) is necessary, so to concentrate the rays of light proceeding from an object, as to form a small and lively image of it, (as in marginal plate, fig. 5,) so, in the same manner, an essential part of the eye is the lens, which brings the rays of light to a focus; and that the lens may make the rays proceeding from an object converge into an accurate focus, so as to form a distinct image on the eye, the vitreous humour is interposed betwixt the lens and the surface of the retina: again, it is necessary to the constitution of the eye, that, in order to increase the sphere of vision, the anterior part of it shall project and form a large segment of a small circle, so as to take a greater circumference into the sphere of vision than could have been done, had the larger sphere of the eye-ball been continued on the fore part. Another necessary part of the apparatus of the eye is the iris, which is a curtain in the anterior chamber of the eye, perforated with a hole, which is capable of being enlarged or diminished so as to admit a larger or smaller stream of light as may be necessary to perfect vision. In this provision, we see the necessity of the anterior humour of the eye being different from the others; being merely an aqueous secretion, while the others possess a degree of firmness, viz. that the iris, or curtain of the eye, may move with perfect freedom in it.

Fig. 6.



The three humours of the eye are thus situated, and have this general character:

1. The **AQUEOUS HUMOUR** is the anterior humour of the eye. It distends the anterior and pellucid part of the eye, so as to increase the sphere of vision. It is perfectly fluid, and of a watery consistence, that it may allow free motion to the iris.

2. The **LENS OR CRYSTALLINE HUMOUR** is placed immediately behind the perforation in the iris; which perforation is called

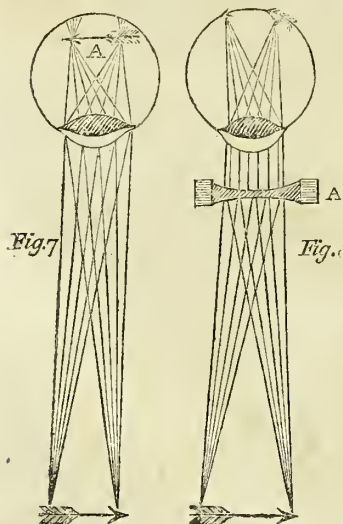
the pupil. The lens collects the rays of light like a double convex glass, so as to concentrate them, and make a more forcible image on the bottom of the eye.

3. THE VITREOUS HUMOUR is behind the lens. It distends the general ball of the eye into a regular sphere, that it may move easily in the orbit; and its diameter in the axis of the eye is so proportioned to the focal distance of the lens, (affected also in some degree by the other humours,) that the image of an object is formed accurately on the surface of the retina: accordingly, when the coats are cut from the back of the eye, the picture of a luminous object held before the pupil is seen exquisitely minute and distinct on the bottom of the eye.

While these humours have each its distinct character, they possess, in proportion to their density, different powers of refracting the rays of light. This has the still farther good effect of correcting the aberration of the rays and giving the truest colours, as well as the most correct image of the object presented to the eye.

If the lucid anterior part of the eye be formed too prominent, or if the lens of the eye have too great a degree of convexity, or, lastly, if the size of the ball of the eye, and the diameter of the vitreous humour in the axis of the eye be unusually great, then the person does not see distinctly; because the powers of the humours, in concentrating the rays of light, are too great, and the image of the object is not formed accurately

on the retina, but before it. Thus, in fig. 7., the convexity of the cornea, the lucid anterior part of the eye, or the focal powers of the lens, being too great for the length of the axis of the eye, the image is formed at A before the rays reach the surface of the retina; and after coming accurately to the point, they again begin to diverge; which diverging rays, striking the surface of the retina, give the indistinct vision of a near-sighted person. But as this indistinctness of vision proceeds from no opacity, but only the disproportion of the convexity of the eye to the diameter, the



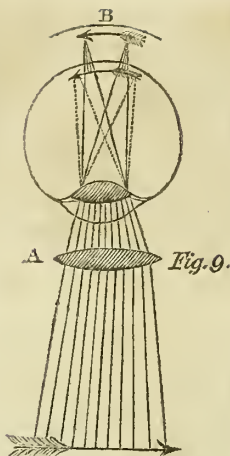
defect is corrected by the concave glass, A fig. 8.; for, the effect of this glass being the reverse of the convex, it causes the rays to fall upon the surface of the eye, so far diverging from the perpendicular line, (which is exemplified in fig. 1.,) as to correct the too great convergence caused by the convexity of the humours. But, when a near-sighted person has brought the object near enough to the eye to see it distinctly, he sees more minutely, and, consequently, more clearly; because he sees the object larger, and as a person with a common eye does, when assisted with a magnifying glass or convex lens.

The near-sighted person sees distant objects indistinctly; and as the eye, in consequence, rests with less accuracy upon the surrounding objects, the piercing look of the eye is diminished, and it has a dulness and heaviness of aspect. Again, the near-sighted person knits his eye-brows, and half closes his eye-lids: this he does to change the direction of the rays, and to correct the inaccuracy of the image, in a manner which may be understood by the following analogy. If we make a card approach a stream of light passing through the window, it will so attract the rays of light, as to extend the margin of the figure of the circular spot of light upon the wall. In the same way, when a stream of light, proceeding from an object towards the eye, is made to pass through a small hole, the circular margin of the hole so attracts the rays, as to produce the same effect with the concave glass; by causing the rays to take a direction outward, as if proceeding from a nearer object, the image is carried farther back from the lens; and when a near-sighted person peers through his eye-lids, it makes the rays impinge accurately upon the retina.*

The effect of old age, is gradually to reduce the eye to a less prominent state, and, consequently, to bring it to the reverse of the near-sighted eye.

From the decrease of the humours, and the lessened convexity of the cornea, the image of objects is not formed soon enough to impinge accurately on the retina, the rays tend to form the image behind the retina, as we see in fig. 9.

* Short-sightedness may be produced by accidents. Sometimes I have known it produced by a piece of glass sticking in the cornea, and causing great inflammation. Dr. Briggs mentions the case of an old man, who had long used spectacles, becoming suddenly short-sighted, by catching cold, and he was afterwards enabled to read the smallest print without glasses. In general, however, it is by some accident, and often late in life, that we become sensible of being short-sighted; and, in this case, men are very apt to attribute the defect to some particular occurrence.



In this figure, we have the effect of old age on the humours represented; without the intervention of the glass A, the rays have a direction which would form the image at some distance beyond the retina, as at B. But by the convex glass A, (which is of the nature of the common spectacles for old people,) the direction of the rays of light is so corrected, that the image falls accurately on the bottom of the eye.

We understand, then, whence these opposite defects of sight arise; that, in old people, objects cannot be seen distinctly when near, and, in short-sighted people, they cannot be seen distinctly when at a distance. We see, also, why old age corrects short-sightedness by gradually reducing the convexity of the eye, enabling the person to see objects farther removed, until, by degrees, he comes to see perfectly at the distance most convenient for the common affairs of life.

It has been, by some, thought extremely difficult to account for the image appearing to us, as it is in nature, erect, since it is actually figured on the bottom of the eye in an inverted posture: but the terms above and below have no relation to the image in the bottom of the eye, but to the position of our bodies and the surrounding things. When I look to a tall man's face, I direct my eyes upward; I observe his situation, as it relates to an ideal area before my eye, or to a space in the sphere of vision.

When an object approaches towards the eye, the diameter of the picture on the retina increases in the same proportion as the distance between the eye and the object decreases; and, consequently, it decreases in the same proportion as the distance increases. But the degree of brightness of the picture of an object on the retina continues the same at all distances, between the eye and the object, unless some of the rays of light are interrupted in their progress; for, as the advancing object becomes bright, it increases doubly in length and breadth, or quadruply in surface. The faint appearance of remote objects, therefore, is occasioned by the opacity of the atmosphere.

There is nothing more astonishing in the structure of the eye, than the sensibility of the expanded nerve, as proved by the extent of the changes or degrees of light which illuminate

visible objects ; or the great degree of light which the eye can bear, and the low degree of light at which objects are visible. Thus, the proportion betwixt the degrees of light illuminating an object by the sun, and by the moon, at any equal altitudes, is calculated at 90,000 to 1.* Again, by M. de la Hire's calculation, we see the sail of a windmill, six feet in diameter, at the distance of 4000 toises. The eye being supposed to be an inch in diameter, the picture of this sail, at the bottom of the eye, will be the eight thousandth part of an inch, which is the 666th part of a line, and is about the 66th part of a common hair. This gives us an idea of the minuteness of the structure of the optic nerve.

The pupil of the eye is formed by the central perforation in the iris or curtain, which hangs before the lens. This body having muscularity, is moveable ; it dilates or contracts the hole or pupil, transmitting the rays so as to adapt the diameter of the stream of light, darting into the eye, to the intensity or degree of light. If a body is illuminated but faintly, the pupil is (insensibly to us) enlarged ; and a greater quantity of the rays are allowed to be transmitted to the retina. But as the convexity of the pellucid part of the eye, and the concentrating powers of the lens, remain the same, the size of the image is not altered by this dilatation of the pupil, but only the strength of the image or picture in the bottom of the eye is increased.

We understand that the rays of light are refracted, when they pass out of one medium into another of different density.— For example, the rays of light are refracted towards the perpendicular line, when they enter the cornea of the human eye ; but they will be refracted in a very small degree in entering the cornea of fish, because the aqueous humour is of the same density with the fluid from which the rays of light are transmitted ; accordingly, the cornea of fishes is not prominent : this would limit their sphere of vision, were not the flatness of the cornea counteracted by the prominence of the whole eye, and the more anterior situation of the crystalline lens ; a large pupil and long diameter of the eye we shall afterwards find to be necessary to the distinct vision of fishes.†

It is natural, on the present occasion, to inquire into the effects of the several humours of the eye, in producing in those

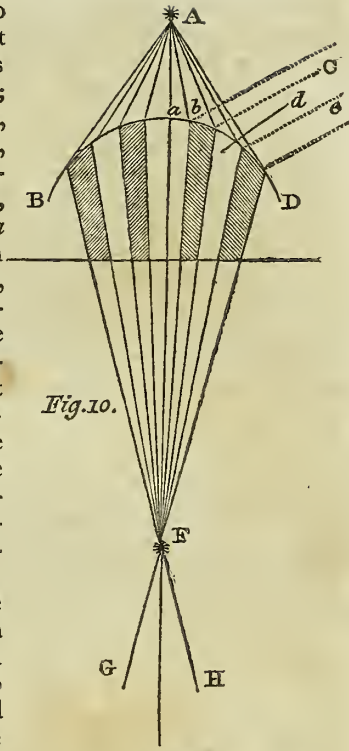
* See Smith's Optics, vol. i. p. 29.

† Neither fish out of water, nor other animals within water, can see an object distinctly. Divers see objects as an old man would do through a very concave glass put near to the eye ; and it has been found, that the convexity of spectacles for divers in the sea must be that of a double convex glass, equal on both sides to the convexity of the cornea. The necessity of this is plain ; the aqueous humour being of the same density with the water, there is in it no refraction, and this deficiency must be supplied.

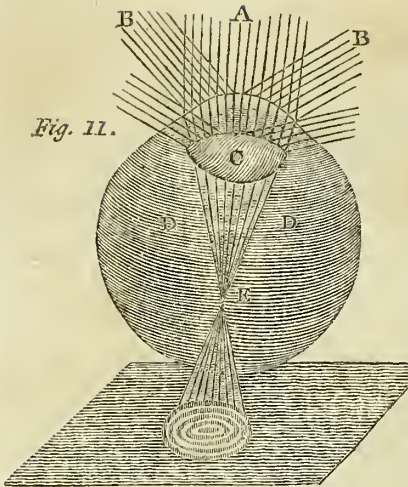
who are short-sighted, the obscurity arising from the double appearance of small and shining points. This is prettily explained by Jurin, upon Sir Isaac Newton's principle, concerning the fits of easy refraction and reflection of light.

The horns of the new moon, or the top of a distant spire, or the lines upon the face of a clock, appear double or triple, and sometimes much more multiplied, to a short-sighted person.—The same appearance will be given when an object is held too near the eye, for perfect vision. If the light is seen through a narrow slit in a board, and the board is brought nearer to the eye than the point of distinct vision, the aperture will appear double, or as two luminous lines, with a dark line between them ; and as the distance is varied, two, three, four, or five dark and luminous lines will be observed. There are many such deceptions in viewing luminous bodies ; all of them proceed from the same cause, which is this:—Before Sir Isaac Newton's philosophy was acknowledged, it was the received opinion, that light was reflected from the surface of bodies by its impinging against their solid parts, and rebounding from them like a tennis-ball when struck against a hard and resisting surface : further, as they saw that part of the rays of light were in glass reflected, and the rest transmitted, they conceived that part entered the pores of the glass and part impinged upon its solid parts. But this does not account for the refractions which take place when the rays have passed the glass, and are about to be transmitted into the air, they cannot find solid parts to strike against in entering the air, for the refraction of the light is greater in passing from the glass into the air, than from the air into the glass ; and if water be placed behind the glass, the refraction of rays passing out from the glass is not increased but diminished, by this substitute for the rarer medium of the air. Again, when two glasses touch each other, no refraction is made in rays passing from the one into the other. To explain this, Sir Isaac Newton taught, that in the progress of rays of light, there is an alternation of fits of easy transition or reflection ; or, in other words, that there is a change of disposition in the rays, to be either transmitted by refraction, or to be reflected by the surface of a transparent medium. Jurin illustrates this opinion, and its application to our present purpose, in this manner.

Suppose that $A B D$, and $B D F$, are mediums of different density, and that their surfaces are interceded by the line $B D$; again, let A be a pencil of rays, which, issuing from this point, falls upon $B a D$, as the refracting surface $B a D$ is convex, and no two points of it, from a to D , are equally distant from the source of the rays A ; and, as the rays of light, in their progress, alter alternately from the fit of refraction to the fit of reflection, they must be in part refracted to the focus F , and reflected in the direction of the dotted lines $c e$. Thus, if the ray $A a$ happens to be in disposition to pass through the medium $B D F$, it will pass on towards the point F . If the next ray $A b$ should be in no fit to be transmitted, because, being in a degree farther advanced from its source A , it has changed to the fit of reflection, then it will not be refracted towards the focus F , but reflected off towards c ; but, again, the ray $A D$ being advanced farther from its source, it will impinge upon the surface $B D$, during its disposition to refraction, and will concentrate its beams at F ; and so with all the others, alternately reflected and refracted.



The consequence of this obstruction to the equal refraction of light, is, that the image formed at F is feeble; but still it is distinct and perfect; because the transmitted rays are regularly concentrated, and form the proper focus. But if the converging rays should be received upon a plain before they arrive at the focus F , the reflected rays of light will have left spaces dark where they would have fallen by refraction, and, consequently, distinct luminous circles will be thrown on the plain: again, if the plain surface be opposed to the rays, after they have formed their focus, and are again dispersing after having crossed, the same unequal effect of light and dark circles will be thrown on it; though now, the rays of the right side of the pencil $B D F$, will form the left of the pencil $F G H$.



How the changeable state of the rays produces the indistinctness of the near-sighted eye, may be understood from this (11.) diagram.—When the rays *A* strike the convex surface of the cornea, part of them will be reflected from the surface of the cornea, in the direction of the lines *B B*, when they will consequently strike upon the convex surface of the lens in luminous rings, these rings will be still farther multiplied and diminished in diam-

eter, in being in part transmitted, in part reflected, from the surfaces of the lens *c*, and vitreous humour *D D*. These effects of the alternate disposition of the rays for transmission and reflection would not be perceptible, did the converging powers of the cornea and lens bring the focus of the rays exactly to the surface of the retina; but as the focus is formed at *E*, some way before the retina, the rays have decussated and spread out again before they form the image upon the bottom of the eye. Instead, therefore, of forming an accurate image, they are spread out into concentric circles; or in a lesser degree, the person experiences a confused outline of the object, which becomes surrounded with several rings or false outlines.*

* By *fits of easy transition*, it was not meant by Sir Isaac Newton that the rays must necessarily be transmitted through every pellucid medium, and at any obliquity of incidence, but only that the ray was more easily transmitted and more difficultly reflected; nor was it meant that, during its *fit of easy reflection*, it was absolutely incapable of being transmitted, but only more readily reflected than transmitted.

CHAP. II.

OF THE COATS OF THE EYE.

SPEAKING generally, and without considering the minuter divisions of anatomists, we may say, that there are three proper coats of the eye, viz. the **SCLEROTIC COAT**, giving strength; the **CHOROID COAT**, being the vehicle of the chief vascular structure of the eye; and the **RETINA**, or expanded nerve, being the organ itself. These are the proper coats of the eye; but there are others which may be called the partial or accessory coats, being those which do not completely surround the eye, viz. the **ALBUGINEA** and **CONJUNCTIVA**.* There are others, still, which are called capsular coats; and these are the transparent tunics which immediately surround the humours, as the capsule of the lens and pellucid membrane of the vitreous humour.

Although many of these coats may be capable of being divided by the art of the anatomist, either by the knife, by injections, which form extravasation between their layers, by maceration, or by the chemical action of fluids; yet it is better, in a general enumeration, to take a natural division and character, than to enumerate their several lamina.

OF THE SCLEROTIC COAT.

The sclerotic coat is so called from its hardness.† The sclerotica and cornea are often considered as one continued coat investing the eye; hence they say, the opaque and the lucid cornea. But, although these parts are actually in union, yet as they are really of so very different a nature, we must consider them apart, and treat at present only of the opaque white sclerotic coat.

The sclerotic coat is a strong, firm, and white membrane, consisting of lamellæ firmly attached and interwoven, and not capable of being regularly separated by maceration; it has the denseness of tanned leather. In firmness, whiteness, opacity, and the little appearance of vascularity, it more resembles the dura mater than any other membrane of the body.

In adults, the sclerotic coat is stronger and firmer, com-

* Colombier Sandifort Thes. Differt.

† Dura seu sclerotica; Vesalius, Ruysch, &c.

paratively, than in the fœtus ; the cornea less so. On the outer surface, it has (towards the orbit) a loose cellular membrane attached to it, which allows the motion of the eye-ball. Upon the fore part, it is invested by the tunica albuginea or tendinea. Upon its inner surface, it has a loose and soft membrane which connects it with the choroid coat.

In birds, and the tortoise, the posterior part of the sclerotic coat is thin ; the fore part of it is split into laminæ, betwixt which there are interposed thin plates of bone,* while in fishes it is in part cartilaginous,† but thin and transparent, so that there appears a very beautiful spotted coat beneath it. There are also seen in the sclerotic of fishes little white granules like glands.

The vagina of the optic nerve can be separated into two laminæ;‡ the outer one is observed to unite intimately with the outer part of the sclerotic coat, while the inner lamina of the vagina is continuous with its inner surface. The pia mater, too, says Zinn, when it has pierced the foramen in the sclerotic coat, along with the substance of the nerve, expands upon the inner surface of this coat, and extends even to the cornea, and forms one of its intimate laminæ. This must be only that part of the pia mater which invests the optic nerve, or, more strictly speaking, that membrane which stands in the same relation to the nerve that the arachnoid coat does to the brain ; for the membrane, which sinks into intimate union with the nerve, accompanies it even in forming the retina.§

The sclerotic coat is the great support of the globular figure of the eye ; it defends the more delicate internal structure from slighter injuries by its strength, and from the progress of inflammation, by being of a structure but little vascular, and not prone to disease. That inflammation which we see to be

* Cuvier, vol. I. p. 387.

† Morgagni Epist. An. xvi. 40. Cuvier, 388.

‡ Ruysch, Zinn.

§ It may be well, in this place, to detail at once the opinions of the chief supporter of that scheme of the coats of the eye, which derives them all from the investing membranes of the brain and optic nerve. M. le Cat, in his *Traité des Sens*, describes them thus:—When the optic nerve has entered the orbit, the dura mater, which surrounds it, splits into two laminæ ; the external one attaches to the orbit, and forms the periosteum, the other forms the vagina of the nerve. In the angle formed by these, the muscles of the eye arise. This continued sheath of the nerve, he continues, expands into the globe of the eye, as the mass of glass is blown into a bottle. The dura mater of the nerve is expanded into the cornea (viz. sclerotica.) The second envelope, or pia mater, forms two laminæ ; the one is applied to the sclerotic coat, and the other forms the choroid coat. The choroid coat divides anteriorly, and forms the iris and ciliary processes. The internal medullary part of the optic nerve forms the retina. Finally, “ L’œil est tres évidemment l’extrémité nerveuse épanouie boursoufflée en bouton creux & plein de liqueurs.” p. 158.

so frequent in the eye, is not in the sclerotica, but in the adventitious coat, the conjunctiva. But in proportion as the sclerotic coat resists pressure and the progress of disease from without, it resists the swelling of the parts within when they become diseased, and gives the greatest torture.

Of what importance the entireness of the coats, and the uniform resistance of the humours of the eye is to the healthy state of the organ, will be afterwards examined.

OF THE CORNEA.

The cornea is so called, from being firm, transparent, and composed of laminæ.* It is the pellucid circle on the fore part of the eye, which seems variegated with colours; though this is a deception, owing to its perfect transparency. The circle of the cornea is, however, far from being regular; its margin is flat towards the nose.

The cornea consists of laminæ; betwixt which, there is interposed a cellular substance, filled with a perfectly pellucid fluid†. These cells seem, like the common cellular membrane of the body, to have a free communication with each other, so that the fluid freely exudes, and as quickly is imbibed, by maceration. The fulness of the cornea, with the perfect transparency of the fluid, gives a brilliancy to the eye, and is a sign of health; the reverse dims the eye, and, with the fallen features, accompanies ill health. Steno observed, and Petit confirmed, the fact‡, that the pores on the surface of the cornea exuded the fluid which fills the cells of the cornea; and that, after the surface was carefully dried by pressure, the moisture might be seen to form in drops upon the surface. The moisture can be thus forced out from the pores of either surface of the cornea.§ This moisture becomes dull and clammy on the approach of death, and forms sometimes a pelticle over the cornea. The laxity with which the laminæ of the cornea are connected, may be, in some measure, demonstrated, by taking it betwixt the finger and thumb; we shall then find, that the layers can be made to glide very freely on each other. In the fœtus, and in young children, the cornea is of great thickness, and resists the point of the lancet or scissors. This resistance in the fœtus proceeds from a great degree of toughness, while, in the adult, the surface of the cornea is so hard, that I have often seen the point of the knife,

* "Cornu modo dura, & cornu instar in laminas dividi radique potest."—Vesalius.

† Substantia spongiosa Valsalvæ.

‡ See also Hovius, p. 82.

§ Zinn.

in extracting the cataract, bend upon it. This turning of the elastic point of the knife is very apt to give a wrong direction to the incision ; and, indeed, this occurred to me in my first operation.

There is a pellicle, or exceedingly thin coat, which by maceration, can be taken off from the surface of the cornea. This is generally understood to be the conjunctiva continued over it. But I cannot help expressing myself as averse to the ideas of those anatomists who consider every membrane, which can be traced from another by dissection, as either derived from it, or in any way allied to it. This can surely serve no useful purpose, if, as here, the membranes differ in their use ; are changed in their appearance ; and have no similarity in structure, function, or diseases.

The membrane in fishes, analogous to the adnata, lies loose over the cornea ; and, in serpents, it is thrown off from the cornea, with the scales of the body, and remains attached to the cast skin of the head ; and in the fœtus calf, I have forced the blood in the vessels of the conjunctiva into vessels passing over the surface of the cornea.

By maceration, I have found, raised in the fluid, a very delicate and transparent membrane from the inner surface of the cornea ; and, after long continued soaking, the whole cornea can be taken out of the sclerotic coat, like an optician's glass from its frame.

The cornea possesses great sensibility ; although much of the pain, from hard bodies flying into the eye, is to be attributed to the motion of the eye-lids, and the great sensibility with which they are endued. When a splinter of glass or metal strikes and sticks in the cornea, inflammation is excited ; in consequence of this, vessels carrying red blood strike into it, or shoot over its surface in a new film of membrane.* Petit thought he observed first in a negro, and afterwards in a variety of instances, red lines in the cornea ; which he conceived to be the anastomosing of vessels. There are, besides, says he, many circumstances which argue that there are blood-vessels in the cornea. When the eye receives a stroke, there is often blood effused in its substance ; abscesses, also, are found within it, and phlyctænæ on its surface ; and in great inflammation of the eye, the cornea appears red ; which, he supposed, must be produced by the same cause which makes

* I have found the spark from iron, in blacksmiths and masons buried in the cornea for several days, (some authors say months,) without exciting pain or much inconvenience. I have also more than once picked a little black slough from the cornea, mistaking it for a piece of iron, when it was only the consequence of the injury.

the albuginea red, viz. the enlargement of its vessels, and the circulation of red blood. But we must not imagine, he continues, that, in the natural state, red blood circulates in the cornea; for the vessels are not to be seen with the microscope; nor are they penetrated by injection; nor do they appear in the fœtus; nor, when little abscesses are formed in the cornea; but only when violence has been done by a stroke upon the eye. In an eye in which the tunica conjunctiva was most minutely injected, as well as the internal vessels of the eye, I had resolved, carefully to examine the structure of the cornea; and after a long maceration, in which it had greatly swelled, I observed a set of vessels totally distinct from the extremities of the minute blood-vessels. The minute blood-vessels which were injected, stopt abruptly on the margin of the cornea. But these I now mention are particular; they are in great profusion, large, and perfectly pellucid; they are large towards the middle of the cornea, and diminish towards the margin. Their free communication formed a net-work deep in the thickened substance of the cornea. The size, perfect pellucidness, and intimate connection of these vessels, might perhaps incline one to call this a cellular structure.

Mr. Home* says, that an irritation on the edge of the cornea, and which includes the tunica conjunctiva, will produce greater inflammation, and more quickly, than a stronger excitement would produce on the centre of the cornea. This remark is probably from observation; but he adds, it is impossible that the vessels of the cornea, which naturally carry lymph only, or serum, can be made to carry red blood, unless the irritation extends to some neighbouring part supplied with red blood. This, certainly, is an erroneous idea; for the little opacities which surround spiculæ sticking in the cornea, the ulcerations on its surface, and little abscesses within its layers,† are the effect of inflammation of the part modified by its peculiar structure; and these will all take place while the margin of the cornea remains clear, and there is no apparent connection of inflammation, or of vessels with the conjunctiva.

Vessels attach themselves both to the inner and to the outer surface of the cornea; and when it becomes spongy and vascular in this way, little can be explained of its natural structure. Thus, the pannus and pterygium are membranes which stretch across and adhere to the cornea, while the iris frequently attaches to its inside. In this case, the cornea becomes spongy,

* Philos. Trans. 1797, p. 20.

† Viz. Onyx, unguis, an abscess between the laminæ of the cornea, from a supposed resemblance to the figure of a nail pared from the finger.

thick, and vascular ; and, when cut, there is red blood in it ;* and in staphyloma, † the iris is generally attached to the cornea. I have a preparation in which the form and character of the iris is entirely lost ; it is extended into a reticulated membrane which lines the surface of the extended cornea.

OF THE CHOROID COAT.

The choroid is the vascular tunic of the eye ; it is so called from its resemblance to one of the membranes of the secundines. It is the middle coat of the eye, lying betwixt the sclerotic coat and retina. Injections show it to consist of two layers of cellular tissue ; and it has upon its inner surface a pigment, which being sometimes firm, might be taken for a membrane. It was Ruysch who observed this division of the choroid coat into two laminæ ; and the inner one, his son called the tunica Ruyschiana : but of these hereafter.

Those anatomists who supposed the sclerotic coat to be the production of the dura mater, naturally concluded, that the choroid coat was derived from the pia mater ; and as Ruysch found it to be divisible into two laminæ, so Sladius found the pia mater to consist of two membranes. It followed, that the one lamina of the choroid coat was the continuation of the tunica arachnoides, and the other of the pia mater ; but this account of these membranes has no support from observation.—Betwixt the pia mater and choroid coat, there is no resemblance ; the latter we shall find loaded with vessels ; but these vessels are peculiar, and minister to a secreting surface. The pia mater in the brain, and optic nerve, is in strict union with the substance of the brain, and supports and nourishes it ; but the choroid coat has no connection with the retina or expanded nerve.

There can be no better mark of distinction between membranes than their degree of vascularity, and particularly in the manner of the distribution of their vessels. The choroid coat is most particular in the distribution of its arteries and veins. The great arterial vascularity of the choroid coat is to be seen only after a very minute injection, and the venous vascularity after artificial or accidental infarction of the blood, or by a successful injection from the superior cava ; although the very

* PTERYGIUM, is a membrane which extends over the cornea from the canthus. PANNUS, is a congeries of blood-vessels, which extends over the cornea, and is less uniform than the pterygium.

† STAPHYLOMA UVEA, a protrusion and opacity of the cornea : which, from the loss of transparency and the general appearance of the tumour, is supposed to resemble a grape.

great vascularity of this coat was known to our oldest writers, yet the appearance of these vessels, when empty, has deceived many. Morgagni* and Maitre-jean, have described fibres which they affirm to be distinct from the vessels, but which prove to be, in fact, the appearance presented by the collapsed vessels.

The great peculiarity of the choroid coat, is its being a secreting membrane; by which I mean, that the pigmentum nigrum which is applied to the medullary lamina of the retina being a secretion, the choroid coat has necessarily that peculiar structure of vessels which belongs to the secreting membrane. This structure has enabled anatomists to tear it into laminæ. For that part of the choroid coat next the sclerotic coat, is merely a vehicle of vessels and nerves, and is a tissue of them connected by very fine cellular membrane. The internal part, again, is organized into a secreting surface, and is the tunica Ruyschiana. I conceive, that the division into the choroid coat and tunica Ruyschiana, is warranted from the nature of the membrane, as the divisions of the coats of the intestines are.

Morgagni says, that from his earliest youth, he had many proofs that the choroid coat was not single in brutes; he asserts, also, that Franciscus Silvius and Guenellonius had demonstrated the double laminæ of this membrane before Ruysch.† Certain it is, that Ruysch was not so fortunate in ascribing a use to this tunica Ruyschiana. He supposed that it gives strength to the choroid coat, and, by bringing a greater afflux of arterial blood, supplies the necessary heat to the otherwise cold humours.‡

TAPETUM. The internal surface of the choroid coat has been long called tapetum, from its villous or fleecy appearance, when seen through the microscope. This surface in the adult is of a brown colour; in very young subjects it is red and bloody; and, when minutely injected, it is like scarlet cloth.—It is by this vascular surface or tapetum that the black pigment, which is laid under the expanded retina in the human eye, is secreted.

THE PIGMENTUM NIGRUM. The pigmentum nigrum is the black or deep brown mucous substance which lies between the choroid coat and retina. It is of a nature to be washed away

* Morgagni Epist. Anat. xvii. 2.

† Idem. ibid. 3.

‡ Quod ad usum tunicæ Ruyschianæ attinet crediderim hanc tunicam inter ceteros usus esse destinatam, non solum ad robur choroideæ, verum etiam ut a sanguinis arteriosi majori copia requisitus calor tribus humoribus natura frigidis conciliaretur. Ruyf. Responf. ad Christ. Wedelium, p. 14.

with a little water and a soft pencil.* This brown taint pervades the whole texture of the choroid coat. This matter is in immediate contact with the medullary pulp of the optic nerve. Its use is apparently to stifle the rays of light after they have impinged on the sensible surface of the retina; for we know that blackness is owing to the absorption of the light, as whiteness and colour are the reflection of it from the surface of bodies. The dark colour of the secreted pigment of the choroid coat is, in some measure, peculiar to those animals which see in the brightest light of day; but is wanting, or of a bright reflecting green or silvery whiteness, in such as prowls by night. The natural conclusion, therefore is, that the pigmentum nigrum subdues the intensity of the impression, while the reflecting colours of the surface in animals which see in the night, strengthens the effect of the light on the surface of the retina, by repelling it. As fishes have the other provisions for seeing in an obscure light, they have also this of the reflecting surface of the tapetum: as it is a secretion of the villous surface of the choroid, we see why it becomes somewhat deficient in old men, and sometimes wanting in the degenerate varieties of animals; when entirely deficient, the blood circulating in the vessels of the choroid coat gives a livid redness to the reflections from the bottom of the eye.†

Finally, in regard to the choroid coat, we have to understand that it consists of two laminæ: the outer, and that which is next to the sclerotic coat, being the proper choroid; the internal lamina, the tunica Ruyschiana: that on the surface of the tunica Ruyschiana, there is a pile or fleece, which is called tapetum: and, lastly, that the secretion of this inner surface is a pigment, which, in the human eye, has the appropriate name of pigmentum nigrum; but, in many animals, it is of a silver, golden, or Isabella colour; though, in my apprehension, the colour, in all these varieties, depends still upon a peculiar secreted matter.

* I cannot conceive how this matter should be confounded with the tapetum or tapis, which, as the name implies, is the villous surface of the choroid coat.— Tapetum is, properly, cloth wrought with various colours; and the analogy was first used by the French Academicians, in their account of the dissection of a lion's eyes. "The membrane which is put into the bottom of the eye, and laid on the choroides, which we call the tapetum, was of an Isabella colour, intermixed with a greenish blue. It was easily separable from the choroides, which remained entire, with its ordinary thickness, after that we had taken away the membrane which forms the tapetum." The explanation of this, I suppose, will be found in Morg. Epist. An. xvii.

† As the pigmentum nigrum is a secretion, we shall not be surprised to find it become deficient in the commencement of some diseases of the eye. This is known by the possibility of seeing to the bottom of the eye: that is, the choroid coat becomes a reflecting surface, and throws out the beams like a cat's eye. See Med. Obser. and Enquiries, vol. iii. p. 124.

OF THE CILIARY PROCESSES.

The ciliary processes are formed of the anterior margin of the choroid coat ; they give the appearance as if the choroid coat, at the anterior part, were folded inward to the margin of the crystalline lens ; and, as if, to accommodate it to this sudden inflection, it had been plated, and not regularly contracted ; at least, this is much the appearance of the circle of ciliary processes, when, after cutting across the eye, we look from behind upon the lens in its natural situation. In this view, we find the pigmentum nigrum of the choroid coat continued over the ciliary processes, which gives to them the appearance of the regular plicæ of the choroid coat, converging to the edge of the lens, and forming altogether a disk round it.

When the black paint on the ciliary processes is a little washed away, and when we attentively examine this part, we find the ciliary processes to be actually little oblong plicæ, which gradually arise from the choroid coat at the angle of its inflection, and terminate abruptly, approximating, but not attached, to the margin of the lens. When the paint is washed entirely away, the whole circle of these processes appears evidently to be the continued choroid coat.

When not injected, the ciliary processes are pale and loose ; but when minutely injected, they take a perfect scarlet colour ; they resemble, in their uninjected state, the valvular-like doublings of the villous coat of the stomach and intestines. Before the choroid coat is inflected towards the lens, in the form of ciliary processes, it forms a firm adhesion to the sclerotic coat near the circular margin of the cornea, and at the same time is united firmly to the root of the iris. From this, the processes tend inward, and a little backwards ; and are, at their internal extremities, detached from the iris ; nor are they attached to the margin of the lens, but are loose and floating.

When the vitreous humour and lens fall out from the anterior segment of the eye, we find that the plicæ or ciliary processes have left their impression on the anterior surface of the vitreous humour, and also on the intermediate expansion of the retina which extends before the membrane of the vitreous humour. This circular impression of the ciliary processes is called by Haller, *striæ retinæ subjectæ ligamento ciliari*.* I have called this impression HALO SIGNATUS, because it is formed of a circle of radiations, formed by the impression of the ciliary processes, and is not peculiar to the retina, but the retina again makes

* Fascie vii. icon. ocul.

its impression on the membrane of the vitreous humour. The furrows and doublings of the anterior part of the retina, formed by the impression of the ciliary processes, Dr. *Monro* has called the ciliary processes of the retina; but, for my part, I think this a term likely to confound and mislead a student; and we might as well speak of the ciliary processes of the vitreous humour, or of the membrane of the vitreous humour, since they also take the impression of the ciliary processes.*

When the vitreous humour and lens are taken out of the coats, we see also that the ciliary processes have left the stain of the fuliginous paint.† This it is necessary to remark, since I have seen students confound this mark with the ciliary processes themselves. The ciliary processes are of a most elegant vascular structure. Their contorted arteries are beautifully represented in *Zinn's* figure. He traces them from the extreme branches of the choroid coat; but, of their veins, he says nothing further than that they are continued from the branches of the vasa vorticosa, or veins of the choroid coat. The points of the ciliary processes are not attached to the lens, but float loose in the posterior chamber of the aqueous humour;‡ but at a little distance from their points, they adhere to the retina, where it is continued over the anterior part of the vitreous humour. Through this attachment only, are they connected with the lens; for, as we shall find presently, the retina (as a membrane, but not as the sensible retina) is continued over the crystalline lens.§

The ciliary processes, collectively, form a circle round the lens, which I call *corona ciliaris*. This circle forming a perfectly opaque partition, which stifles all rays that might otherwise be transmitted by the side of the lens. The *corona ciliaris*, or ciliary circle, no doubt, serves at the same time as a connexion between the outer and strong coats of the eye and the transparent coats and humours; for, it is to be observed, that, excepting the connection which naturally exists betwixt the optic nerve and retina, this slender hold which the ciliary processes take of the expanded retina, is the only attachment betwixt the humours of the eye and the proper coats.

* *Winslow* uses the term *fulci ciliares*, for the impression on the vitreous humour. *Zinn* calls this *corona ciliaris*, after *Camper*; he describes them well, p. 75.

† See *Morgagni* *Epist. Anat.* xvii. n. 13, and *Ruyfch* also, "Nonnulli pro processu ciliari agnoscunt pullas pigmenti nigri reliquias, membranulæ tenuissimæ humoris cristallini & vitrei, & quasi fibres mentientes oculo sc. aperto, humoribusque exemptis; hæ autem nil sunt nisi avulsæ particulæ pigmenti nigri." *Ruyfch. Thef. An.* ii. *Aff.* i. No. xv.

‡ This was demonstrated in a particular manner by *Ruyfch* and *Morgagni*.

§ *Zinn* and other later writers have entertained the idea, that the adhesion of the ciliary processes to the membranes covering the vitreous humour is by a kind of gluing, rather than a union by cellular membrane. See *Zinn*, p. 75.

In regard to the names appropriated to this part of the eye, there is more confusion than it is possible to believe. It is necessary to attend to this ambiguous use of terms, else we shall be in danger of misunderstanding our best authors. Vesalius considers the whole as a septum betwixt the vitreous and posterior chamber of the aqueous humour; but he seems to find much difficulty in giving it an appropriate name.* Fallopius and Morgagni† use the term *CORPUS CILIARE* for the whole circle of the processes, and in the same sense that I have ventured to use *corona ciliaris*. It is a name which conveys the idea neither of the shape nor of the substance of the thing meant. Ruysch makes great confusion by his use of terms; the *corona ciliaris*, or ciliary body, he calls the *ligamentum ciliare*; and the lines on the back surface of the iris, he calls *processus ciliaris musculosus*; or, rather, he means by this, the straight fibres of the iris.‡ Duverney, with Ruysch and Winslow, following Fallopius, calls the *corona ciliaris* also *ligamentum ciliare*. But the ciliary ligament is used by others in a widely different sense, viz. for the circular root of the ciliary body and iris, the *annulum album cellulosum*, or the *frenula membranoso* of Zinn. By Hovius, what I have called *halo signatus*, is called *ligamentum ciliare*. In Haller's fifth figure of the eye, this circular root of the ciliary processes, is called *orbiculus ciliaris*. Maitre-jean, Haller, and others, call the whole body, or *corona*, the ciliary circle. M. Ferrein, *l'anneau de la Choroïde*, and M. Lieutaud, denominated the ciliary processes "rayons ciliares," and the root of the *corona ciliaris* and iris, "plexus ciliaris."

* "Neque mihi ullum occurrit nomen quod ipsi aptius indam quam tunicæ: aut si voles, interstitii vel septi inter vitreum humorcm & eum quem albugineum nuncubamus repositi." Vesal. vol. i. p. 558.

† *Epist. Anat.* xvii. 11.

‡ Ruysch has this expression: "Ligamentum ciliare neutiquam esse considerandum tanquam muscolum ad pupillæ et humoris cristallini motum destinatum, totumque hoc negotium perfici a processu ciliari ut et a circulo musculari posterius in confinio pupillæ sito." *Thes. Anat.* ii. xv. See also the explanation of fig. iv. of this *Thesaurus*, where we have "Iris enim est facies exterior, processus lig. ciliaris facies interior."

CHAP. III.

OF THE IRIS.

THE iris is the coloured circle which surrounds the pupil, and which we see through the transparent cornea of the eye. It is a membrane hung before the crystalline lens.* It is as if perforated in the middle; and this hole in the middle of the iris is the pupil; and through the pupil only can the rays be transmitted to the bottom of the eye. When we hear of the dilatation and contraction of the pupil, we have to understand the action of the iris, which, by possessing the power of contracting and relaxing, holds a controul over the quantity of light transmitted to the bottom of the eye. For by the extension of this membrane, the diameter of the pupil is diminished, and, by contraction of the membrane, it is dilated. This motion of the iris, and, consequently, the size of the pupil, is connected with the sensation of the retina; by which means, in disease of internal parts of the eye, it is often an index to us of the state of the nerve, and of the possibility of giving relief by operation.

The iris and corona ciliaris, or ciliary processes, are, in general, considered as being the two laminæ of the choroid coat continued forward and split: the internal lamina of the choroid forming the corona ciliaris, and the outer one forming the iris. The former I was willing to consider as the anterior margin of the choroid coat, because it has no distinction in its structure from that coat; but the iris I cannot consider as the continued choroid coat: in the *first* place, because I have found it fall out a perfect circle by maceration; *secondly*, because it has no resemblance in structure to the choroid coat; and, *chiefly*, as by its power of contracting, it shows a widely different character from any of the other membranes of the eye.

The outer surface of this circular membrane gives the colour to the eye during life; and from its beautiful and variegated

* Winflow and Haller, and most of the old anatomists, call this *uvea*; but most of the modern anatomists follow Zinn and Lieutaud, in calling it *iris*; though Lieutaud and others called the anterior surface only *iris*, while they still continued to call this perforated membrane *choroides*, or *uvea*. See Lieut. p. 117. Again, others call the posterior surface of the *iris uvea*, from its likeness to the dark colour of a raisin; and the word *iris* is borrowed, I suppose, from the varied colours of the rainbow.

colours, it has gained to the whole membrane the name of iris. Haller and Zinn, nearly at the same time, explained the cause of this coloured iris, which had been, till then, supposed to be occasioned by the refraction of the light amongst its striæ and fibres.

When this membrane is put in water, and examined with the microscope, its anterior surface is seen to be covered with minute villi. The splendid colouring of the iris proceeds from the villi; but by beginning putrefaction, the splendid reflection fades, as the brilliant surface of the choroid of brutes is lost by keeping. For this reason, I imagine the colour and brilliancy of the iris to depend on the secretion of these villi. But the colour of the iris depends, in a great measure, on the black paint upon its posterior surface shining through it; and the black and hazel-coloured iris is owing to the greater degree of transparency of the iris, which allows the dark uvea to shine through it.

The iris is acknowledged to be the most acutely sensible part in the body. We have, then, to expect in its composition, muscular fibres, and to account for its acute irritability and sympathy, by a profusion of nerves: again, as the power of the muscular fibre, and the sensibility of the nerve, are both, in some measure, indebted to the circulation of the blood, we may expect to find also a profusion of vessels in the iris. In all these respects, we shall find the iris to be an object of admiration.

OF THE MUSCULAR FIBRES OF THE IRIS.

It is evident from a note, under the head *corona ciliaris*, that Ruysch had observed two sets of muscular fibres in the iris; for, under the name of ciliary ligament, he describes a set of radiated fibres which go from the ciliary processes towards the circular margin of the pupil: he observed also, the circular or orbicular fibres which run round the margin of the pupil. Winslow says, that between the two laminæ of the uvea (*viz.* iris) we find two thin planes of fibres, which appear to be fleshy: the fibres of one plane orbicular, and lying round the circumference of the pupil, and those of the other being radiated; one extremity of it being fixed to the orbicular plane, the other to the great edge of the uvea. Zinn describes, with much minuteness, radiated fibres (on the anterior surface of the iris,) but does not consider these as muscular fibres; and he confesses, that he could not observe the orbicular muscle which Maitre-jean and Ruysch had painted. Even in owls and other creatures, having a strong iris, he could not discover

an orbicular muscle ; nor were Haller and Morgagni more successful in this investigation.* Wrisberg also affirms, that no muscular fibres could be seen in the iris of the ox. Dr. Monro, on the other hand, adheres to the opinion of the muscularity of the iris : he describes minutely both the radiated and sphincter fibres. Wrisberg and others have thought they found sufficient proof against the muscularity of the iris, in the fact of its not contracting when the light falls upon its surface. To this Dr. Monro answers, that the colour or paint upon the iris must, like a cuticle, prevent the light from irritating the iris. I cannot think that this circumstance should prevent the excitement of the iris. The retina is in a peculiar manner susceptible of the impression of light ; but we cannot wonder that light should not stimulate a muscle to contraction, when we have every proof that it has no effect on the most delicate expanded nerve of the other senses.

That the iris is to be affected only through the sensation of the retina, or perhaps rather the effect communicated to the sensorium, we have sufficient proof. I have, in couching, repeatedly rubbed the side of the needle against the iris without exciting any motion in it: I have seen it pricked slightly by the needle without its showing any sign of being irritated ; nay, what was too a convincing proof, I have seen it cut by falling before the knife in extracting the cataract: in this last instance, far from being stimulated to contraction, it hung relaxed.†

It is evident, then, that no common stimulus, immediately applied to the iris, has any sensible effect in exciting it to contraction ; and that it is subject only, in a secondary way, to the degree of intensity of light admitted to the retina. The movement of the iris is in general involuntary ; but terror and sudden fright affect it. In some animals, particularly in the parrot, it is a voluntary muscle.‡ As an object, upon which we look, approaches the eye, the pupil contracts, which is an effect of the increasing intensity of the light reflected from the object ; for, as the object advances, it fills a greater space in

* See Zinn, p. 89 and 90. Morgagni. Epist. Anat. xvii. § 4. Haller and Ferrein attribute the motion of the iris to an afflux of humours in its vessels.

† This fact destroys the hypothesis of M. Mery, of the Royal Acad. of Sciences, that the straight fibres of the iris are little cavernous bodies, and that the action of the light upon the retina swelled and elongated them so as to cause the diminution of the size of the pupil ; for, by this cut, they must have fallen from their erected state, and contracted so as to have dilated the pupil. See Acad. Roy. des Sc. 1704, mem. p. 261.

‡ When a cat is roused to attention, as by the scratching of a mouse, it dilates the pupil, which allows a stronger impression on the bottom of the eye ; nay, whenever pufs struggles violently to get loose, the pupil dilates, which may sufficiently account for M. Mery's cat having her pupil dilated when he plunged her under the water. See Acad. Roy. des Sc. 1704, mem. 261.

the sphere of vision, and of course more rays flow from it into the eye.

NERVES OF THE IRIS. The iris is supplied with nerves in great profusion. They are derived from the long ciliary nerves which run forward betwixt the cornea and choroid coat towards the common root of the corona ciliaris and the iris. They there divide, and are seen to pass in numerous branches into the substance of the iris. In the substance of the iris, the branches of the nerves, from their extreme minuteness, are soon lost amongst its pale fibres.

BLOOD-VESSELS OF THE IRIS. I have had preparations which showed so great a degree of vascularity in the iris, that I was ready to believe its action to be produced entirely by a vascular structure; but when, on other occasions, my admiration was excited by the profusion of nerves, and I was led to observe that in the former instances they had been obscured by the injection, I could not but allow that the muscular fibres might have been obscured as the nerves were.

There are four arteries sent to the iris: two long ciliary arteries which take a long course on the outside of the choroid coat, and two lesser and anterior arteries which pierce the ligamentum ciliare from without. These arteries approach the root of the iris at four opposite points, and branching widely form a vascular circle round the root of the iris, viz. the larger circle of the iris. From this circle branches pass off, which run with a serpentine course, converging to the edge of the iris: here they again throw out inosculating branches, which form a circle surrounding the pupil, but at some little distance from the edge of the iris—this is the lesser circle of the iris. From this lesser circle there again proceed minute branches towards the edge of the iris.*

The **VEINS**, which intermingle their branches with these arteries, pass some of them into the vasa vorticiosa of the choroid coat, and others take a long course betwixt the choroid and sclerotic coat, accompanying the ciliary nerves, whilst some branches pierce the sclerotic coat at the root of the iris, and become superficial upon the fore part of the eye.

* See Ruyfch Epist. Anat. prob. xiii. p. 31.

CHAP. IV.

PRACTICAL REMARKS DEDUCED FROM THE
STRUCTURE OF THE CHOROID COAT AND
IRIS.

THE choroid coat, ciliary processes, and iris, being the most vascular parts of the eye, are frequently the seat of disease, and administer to the disorder in all violent internal affections of the organ. I had always conceived these parts to be chiefly active in the carcinoma of the bulb of the eye, and I had lately an opportunity of observing this in dissection. In this disease, there is first deep pain in the eye, from the inflammation and disorder of the vascular coats; and often the effect of the increased action, within the eye, is known from its effects in enlarging the veins on the surface of the eye-ball.— These vessels being active in their natural state, are very apt to become diseased when disturbed in their action; and although we frequently see the eye quite sunk, yet, when it is burst, and the vascular coats are protuberant, a cancerous state of the eye is to be dreaded.

When the eye is hurt by a blow; when inflammation spreads from the cornea to the iris, in consequence of a small-pox pustule; when an ulcer of the cornea, or an incision of it does not heal quickly, but allows the aqueous humour to distil out, and consequently the iris to fall in contact with the cornea; the iris adheres, and often forms staphyloma. Thus we find staphyloma to follow the operation of extraction, in consequence of the iris protruding and adhering to the wound: again, in staphyloma from small-pox, by the adhesion of the iris to the cornea, while the cornea is extending and perhaps bursts, the iris mixes with the cornea, and gives the ugly black and mixed colours of this disease. I have a preparation in which the cornea had greatly dilated; the iris is extended like a black net-work upon the inner surface of the cornea; and in the usual place of the iris, the ciliary processes are to be seen. The iris adheres also to the capsule of the lens, which is behind it, and, as we shall presently see, close upon it. I saw it in one instance, adhering so strongly to the cataract, that, in attempting to depress the cataract with the needle, the edge of the iris was turned over and depressed with the needle, and the regularity of the pupil was destroyed; of course, here,

there could be no permanent depression, without previously cutting this adhesion.

It was at one time believed, on the authority of many excellent anatomists, that the vessels of the iris were colourless, and did not circulate red blood : after what has been said, it is scarcely necessary to mention the fallacy of this opinion.* I have seen the iris cut and bleeding, though, not profusely as I expected ; the small quantity of blood soon coagulated into a dark speck, while I expected it should have been effused in the aqueous humour.

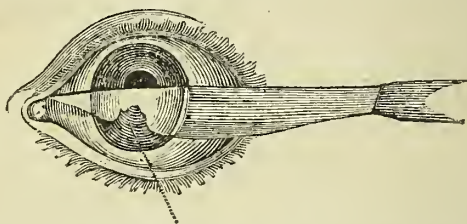
There is a circumstance in the operation of extracting the cataract which I have seen little attended to, and yet it is sufficiently evident. When the cornea has been cut, operators, disappointed in not finding the cataract protruded, keep the eye staring in the light, and press the ball of the eye ; but while the eye is thus exposed to the excitement of the light, the pupil is contracted, and the lens propelled by the action of the muscles ; and, still more, by the pressure made on the eye-ball, is in danger of bursting through and tearing the iris. The best operators have been in the custom of shutting the eye-lids the instant the incision was made in the cornea ; by this means, the eye is for a time supported in some degree during the violent spasm of the recti muscles, and the iris being allowed to dilate, the lens is protruded into the anterior chamber of the aqueous humour through the pupil, and is ready to slip from under the cut cornea, when the eye-lids are again opened. By this means, if the incision of the cornea is of the proper extent, the lens is not *extracted* but is *protruded*, by the action of the muscles of the eye.

It is very necessary for us to remember, that all the parts of the eye in themselves extremely delicate, are kept in their relative places, not by adhesions, but by the complete support they derive from the globular form of the eye, and by the strength of the outer coat or sclerotic and cornea. To this, it is particularly necessary to attend, in the operation of the extraction of the cataract ; for, as soon as the aqueous humour is evacuated, the uniform resistance of the coats of the eye is destroyed, and the muscles surrounding the eye-ball force all the humours towards the incision. It is this circumstance which brings the iris into great danger of being cut when the knife is too narrow to make the incision, at once, by pushing it through the cornea with an uninterrupted motion of the fingers. For,

* Dr. Monro, in treating of this subject, mentions his having seen a net-work of vessels covered with paint darker than that of the iris, and extended from the iris upon the surface of the lens ; and, in another instance, a net-work of filaments passing quite across the pupil. See his *Dissertations*, p. 108.

when the knife is not broad enough to cut itself out by moving it uniformly along, the aqueous humour escapes in the endeavour to cut downwards, and the iris is protruded so as to fall under the edge of the knife; nay, with a good knife, and of a shape to cut itself out, and at the same time adapted to make a cut in the cornea sufficient to allow the escape of the lens, I have seen, in consequence of a hesitating manner of introducing the knife, the aqueous humour suffered to escape. Now, observe the consequence of this:—The lens being pushed outwards by the contraction of the muscles on the eye-ball, towards that point at which the continuity and consequent uniform resistance of the coats were broken, the margin of the iris was forced under the edge of the knife and cut, as I have here represented.

Fig. 12.



The margin of the Iris fallen before the edge of the knife and cut.

A very particular effect of this cut upon the margin of the iris is to be observed.—When the incision has been happily done, the lens is protruded uniformly through the pupil; but when the iris was cut, as now explained, the edge of the lens, opposite to the part of the iris which was cut, was forced forward; the lens was turned sideways, without being entirely displaced; and a great part of the vitreous humour was allowed to escape.

CHAP. V.

OF THE RETINA, AND DIGRESSION CONCERNING THE SEAT OF VISION.

THE term retina has, in a modern publication, been objected to, as improperly applied to the inner coat of the eye.—Such a term, it has been said, may well be applied to the nerve expanded on the lamina spiralis of the cochlea, because it is there formed into an intricate plexus by innumerable joinings and separations of its component parts; but used for the expanded nerve of the eye, the term retina is thought improper.* We must look for the resemblance, however, which justifies this term, not in the medullary matter of the nerve, but in its vessels. “Hanc figuram egregie repræsentat dicta tunica retina cum arteriolæ ceracea materia sunt repletæ.”†

The retina is the expansion of the optic nerve; the immediate seat of sensation, and the most internal of those membranes which are called the coats of the eye. It has been already observed, that there is a distinction betwixt a nerve in its course from the brain to the organ of sense, and where it is actually expanded and adapted to the reception of the external impression. Before the optic nerve has perforated the sclerotic coat of the eye, it is surrounded with a firm sheath; and its substance is evidently composed of bundles of fibres, though not so coarse, yet like those of the nerves in the other parts of the body. The opacity of the nerve makes it have little the appearance of vascularity, but when the body of the nerve is made transparent, it becomes like a red cord; so necessary is it that the medullary substance of the nerve be supplied with blood.

The stronger sheath which surrounds the body of the optic nerve is loose, and may be separated into lamellæ. There is a more delicate membrane which immediately adheres to the surface of the nerve; and its substance is formed into the minute fasciculi which give it the fibrous appearance by a still firmer intertexture of membrane. This interwoven membrane proceeds, with the retina, into the eye; the other sheaths are re-

* Dr. Monro's 4to Treatises.

† Ruysch Epist. Anat. xiii. p. 14. Quemobrem servare adhuc retinæ, appellationem si non ex fibrarum ut certe ex vasorum implicatione, &c. Morgagni Epist. Anat. xvii. § 43.

flected off, and unite with the sclerotic coat. Some little way from the back part of the eye, the arteria centralis retinæ pierces the sheath of the nerve, plunges into the centre, and passes into the eye along with it. If the optic nerve be cut near to the eye, the open mouth of this small artery may be seen; but if we make our section some way removed from the back of the eye, it will, of course, not be seen. The artery contracting and leaving a space in the centre of the nerve when thus cut, (or perhaps it was the open mouth of the artery itself,) was observed by the ancients, and by them called the porus opticus, because they were ignorant of this central artery of the retina.*

Where the optic nerve is about to enter into the ball of the eye, it is much diminished in diameter; it is contracted and condensed, and, at the same time, lays aside the strong coats. The proper nerve then perforates a cribriform lamina in the sclerotic coat. Within the eye, the filaments seen in the nerve are no longer distinguishable; but from the extremity of the nerve the fine web of the retina is produced.

The LAMINA CRIBROSA, and the delicate fasciculi of the optic nerve, are shown in this manner: after making a section of the eye, wash away the retina from the extremity of the optic nerve, and also the choroid coat; then press the optic nerve betwixt the finger and thumb, when the pulp of the nerve will be seen to protrude through the foramina in the sclerotic coat like white points. It is observed by Zinn, that, in doing this, there is a central foramen which remains unfilled up by the compression of the nerve. This is the hole perforated by the arteria centralis retinæ.† Where the threads of nerves are accumulated after passing these foramina, and before they are finally expanded into the retina, they necessarily form a small cone or papilla. This conical form of the extremity of the optic nerve is much more evident in some animals than in others; but in a section of the human optic nerve we may also observe it.‡

The retina is a membrane of the most delicate texture of any in the animal body: it is transparent in the recent state, and so soft, that it will tear with its own weight. In spirits and weak acids, it becomes opaque and firmer. It lies expanded over

* Porum opticum Herophilus et omnis ab ea antiquitas dixit, foramen nempe quod in dissecto nervo de vacua arteria superest. Hall. Arter. Ocul. Hist. p. 42.

† Zinn de oculo humano, p. 106. Com. Reg. Soc. Scient. Gotting. loc. cit. About 30 foramina have been observed in the lamina cribrosa. See Haller Fasc. de Arter. Oculi, p. 42.

‡ Zinn. "At the place which answers to the insertion of the optic nerve, we observe a small depression, in which lies a sort of medullary button terminating in a point." Winflow, p. 78.

the vitreous humour, and contiguous, but not adhering, to the choroid coat, or its pigment. The retina does not consist merely of the expanded nervous matter, but has, in its composition, a very fine membrane, and many minute vessels. When the retina is macerated for a considerable time, the pulp of the nerve can be washed away, and there remains only the reticulated and delicate membrane which supports the vessels that nourish it. But though the pulp of the nerve may be dissolved, it cannot, by dissection, be freed from the membrane which supports it.*

I have a preparation which more resembles some of Ruysch's plates than any I have seen. In this preparation, the nerve being washed away, we may see distinctly the whole course of the arteria centralis retinæ. Of this preparation I have given an engraving, to show how plentifully this organ is supplied with red blood; from which circumstance we may learn the strict dependence of its function on the circulation, and deduce the derangement of the powers of vision, as a natural consequence of the disordered action of these vessels.

The soft medullary matter of the retina is towards the surface of the choroid coat, and forms there a lamina, which appears to me to be the surface of the nerve upon which the rays of light impinge.† The vessels of the retina run upon the surface contiguous to the vitreous humour.‡ The arteria centralis retinæ is derived from the ophthalmic artery. It pierces the optic nerve, as we have already observed, and enters the eye through the porus opticus, to supply the retina. But the arteries of the retina do not always enter into the eye in one trunk; on the contrary, sometimes two or three branches

* "Possè vere medullarem retinæ laminam removeri ut vasculosum rete membranæ figuram retineat, alteramque ab altera integram detrahi ultra hominum artem positum esse videtur nec ulli unquam contigisse, legere me meminì, etfi, deleta macerando medulla, rete vasculosum laminam peculiarem referre videatur. Ex quibus omnibus elicio retinam esse tunicam simplicem, ex cellulosa constaram: que vascula et substantiam medullarem sustinet etfi duas diversas ostendat facies alteram vasculosam interiorem, alteram medullarem exteriorem." Zinn, p. 112.

† "C'est surtout dans les poissons qu'il est facile de distinguer et meme de separer ces deux lames." Cuvier, tom. ii. p. 419.

The opacity of the outer surface of the retina prevents the vascularity from being apparent. Albinus, after a very minute injection, observed, that when he lifted up the choroid coat, the vascularity of the retina was not seen: "Autem de ea aliquid acuto scalpello subtiliter levissimeque deradens, mox conspicio vasa impleta multa quæ sub medulla cujus nimirum portionem deraferam latuerant." Albin. An. Acad. lib. iii. cap. xiv.

‡ Dr. Monro has these words, expressive of an opposite opinion: "The whole appears to be composed of an uniform pulpy matter, on the outer side of which chiefly vessels are dispersed, supported, I suppose, by a membrane the same or analogous to the pia mater." 4to Treatises on the eye, ear, &c.

pierce the lamina cribrosa,* and afterwards, two, three, or four principal branches, spread out on the circumference of the retina; from these, the ramifications are so numerous, that Ruysch describes them as constituting the membrane.† Corresponding with the arteria centralis retinæ in the adult, there are veins, the minute extremities of which, after forming connections with the veins of the corona ciliaris, run backwards on the inner surface of the retina in three or four distinct branches. These uniting into a trunk, perforate the lamina cribrosa, and become the socia arteriæ centralis.

Many have been led to believe, that the retina terminates forward on the roots of the ciliary processes, as others have conceived it to be continued over the fore part of the vitreous humour, and over the surface of the lens;‡ but the most prevalent opinion is, that it terminates on the margin of the lens.

That the retina extends over the back of the lens, and receives there the impression of light, is very improbable; but that the membrane which supports the retina, is continued over the lens, is demonstrable. As I have just said, the retina, I conceive (with Albinus, M. Ferrein, and others,) to consist of two distinct parts, viz. the medulla of the nerve, and a pellucid membrane supporting it; but, however reasonable this conclusion is, I cannot believe that these portions are to be separated by dissection. It is, by most anatomists, believed, that the retina passes forward betwixt the vitreous humour and ciliary body, and adheres to the margin of the lens. Now, as this adhesion is not a gluing together of parts, but a union or intermixture of membranous filaments, the interchange and mingling of fibres, we may safely say, that the membrane of the retina is continued over the lens, and forms part of its capsule. The opacity of the retina is diminished at the root of the ciliary processes, and disappears altogether at the margin of the lens; and here it is not only changed by becoming perfectly transparent and allied to the membranes of the humours, but it becomes also distinguishable from the opaque retina by a greater toughness and strength. The continuity of the retina with the capsule of the lens is more ap-

* Haller loc. cit. Morgagni Ep. Anat. xvii. n. 44. nor do they always pierce the centre of the nerve exactly. Morgagni.

† "Iteratis perscrutiniis reperio oculis armatis arteriolarum extrema tam esse numerosa & tam arcte sibi invicem et intricate annexa ut peculiarem representent membranulam ex arteriolarum extremis constitutam, cui connectitur dicta medulloso substantia." Ruysch Epist. Anat. xiii. p. 15.

‡ Many anatomists, Winslow, Cassobohm, Ferrein, Licutaud, and Haller, have taught that the retina extends over the great convexity of the lens, or that it is inserted into it. Galen believed it to extend over the lens. For an impartial history of opinions, see Morgagni Epist. Anat. xvii. 47, and Zinn, 114.

parent, when both membranes have become opaque by being immersed in spirits or vinegar, but more particularly when that opacity is produced by disease. In disease, I have found the veins of the retina running over the margin of the lens, and branching on its posterior convexity.

Where the retina lies betwixt the vitreous humour and the ciliary processes, it is plaited, and descends into the interstices of these processes.

When we take off the sclerotic and choroid coats of the eye, by dissecting them round the insertion of the optic nerve, and fold them back, carefully preserving the retina; and when we have taken away the ciliary processes from their adhesion, to the fore part of the retina, we find the retina to form a sac surrounding the vitreous humour, and supporting the lens. In all this surface, the membrane is smooth and uninterrupted.—To the margin of the lens all this sac is opaque; because, upon the outside of the retina, is the opaque pulpy nervous matter, but the coats of the lens are transparent, yet continuous with the arachnoid portion of the retina. When these parts of the eye are thus dissected, they hang all together by the optic nerve; viz. the lens, the vitreous humour, and the expanded matter of the nerve being supported by delicate and pellucid membranes, constituting part of the retina; and the organ is divested only of its outer apparatus; we still retain within this the more essential and important parts.



There is here a natural division; and I am willing to pause upon this, knowing well with how much difficulty the student gains a knowledge of the minute structure of the eye, when point follows upon point of the detail, without any resting-place or mark of division and character. All within the connexions of the retina, I shall call the INTERNAL GLOBE of the eye, as distinguishing it from the outward coats of the eye and parts subservient to them. A view of the little vascular system of these internal parts, thus classed, will show how strictly they are connected together, and how much insulated from the other parts.

But this is a subject upon which we cannot venture, until we have considered the nature and relative situation of the humours of the eye.

DIGRESSION ON THE SEAT OF VISION.

M. L'Abbe Marriotte discovered the curious fact, that when the rays fall upon the centre of the optic nerve, they give no sensation. He describes his experiment in this manner:—"Having often observed, in dissections of men as well as of brutes, that the optic nerve does never answer just to the middle of the bottom of the eye; that is, to the place where the picture of the object we look directly upon is made; and that, in man, it is somewhat higher, and on the side towards the nose; to make, therefore, the rays of an object to fall upon the optic nerve of my eye, and to find the consequence thereof I made this experiment. I fastened on an obscure wall, about the height of my eye, a small round paper, to serve me for a fixed point of vision; I fastened such another on the side thereof towards my right hand, at the distance of about two feet, but somewhat lower than the first, to the end that I might strike the optic nerve of my right eye while I kept my left shut. Then I placed myself over against the first paper and drew back by little and little, keeping my right eye fixed and very steady upon the same, and being about ten feet distant, the second paper totally disappeared."*

This defect in the vision of the one eye is corrected by that of the other; for the insertion of the optic nerves being towards the side next the nose, no part of an image can ever fall on the optic nerve of both eyes at once. The effect of vision, therefore, is observed only in very careful experiments. Experiments were, however, made by M. Picard, Marriotte, and Le Cat, to render this effect produced by the image falling on the centre of the optic nerve evident, when looking with both eyes. Marriotte's second experiment was this: place two round pieces of paper at the right of your eyes, three feet from one another, then place yourself opposite to them at the distance of 12 or 13 feet, and hold your thumb before your eyes at the distance of about eight inches, so that it may conceal from the right eye the paper that is to the left hand, and from the left eye the paper to the right hand. If, now, you look at your thumb steadily with both eyes, you will lose sight of both the papers.† The novelty of such a discovery was likely, as

* Vid. Phil. Trans. No. 35. Smith's Optics, Remarks on art. 87.

† Dr. Smith made the stream of light through the key-hole of a dark chamber fall upon this point of the retina, opposite to the termination of the optic nerve, but he found it quite insensible even to this degree of light. M. Picquet asserts, that very luminous objects make a faint impression on the centre of the optic nerve. But Dr. Priestley says, that a candle makes no impression on that part of his eye.

frequently is the case, to carry men's minds beyond the true point. It requires time for such facts to descend to their level, in the scale of importance, with other less novel observations. Marriotte, upon this fact, formed a new hypothesis relating to the seat of vision. We have observed, that the choroid coat and pigmentum nigrum are deficient, where the optic nerve enters the eye, and is about to expand into the retina. He fixed upon the most unaccountable supposition, that the retina does not receive the impression of the rays, but that the choroid coat is the seat of the sense. In support of this theory, he soon found other arguments than those arising from the deficiency of the choroid coat at the entrance of the nerve. He saw that the pupil dilated in the shade, and contracted in a more intense light: now, says he, as the iris is a continuation of the choroid coat, this is a proof of the great sensibility of that coat: again, the dark colour of the choroid coat he supposed to be well calculated for the action of the rays of light, which are not reflected from it or transmitted, but absorbed; while, on the other hand, the retina is transparent. If vision were performed in the retina, says Marriotte, it seems that it should be found wherever the retina is; and since the retina covers the whole nerve as well as the rest of the bottom of the eye, there appears no reason why there should be no vision in the place of the optic nerve. M. Picquet argued in opposition to Marriotte. He observed, in regard to the fitness of the black colour of the choroides for the action of the rays of light, that the choroid is not universally black; that there are many shades of difference in the human eye; and that it is black, blue, green, yellow, or of a metallic shining surface, in a variety of animals. He conceived, that the defect of vision at the insertion of the nerve is occasioned by the blood-vessels of the retina.* He observed, also, that the opacity of the retina is such, as necessarily to obstruct the transmission of the rays of light to the choroid coat. M. de la Hire took part in this controversy. He considered the retina as the organ of sight, although a particular point of it is not susceptible of immediate impression from outward objects; for, says he, we must not conceive sensation to be conveyed by any other means than by the nerves. But, observing the constitution of the other organ of the senses, he entertained an idea that the retina receives the impression in a secondary way, and through the choroides, as an intermediate organ; that, by the light striking the cho-

* Against this hypothesis, the size of the insensible spot was urged by Marriotte. Bernuouilli calculated that this spot is a circle, the diameter of which is a seventh part of the diameter of the eye, and that the centre is $\frac{27}{100}$ parts of its diameter, from the point opposite to the pupil and a little above the middle.

roid coat, it is agitated, and communicates the motion to the retina; and we find that, through all the organs of the senses, he continues, the nerves are too delicate to be immediately exposed to the naked impressions of external bodies.

Another objection to the opinion, that the retina is the seat of sensation, has been lately urged, viz. that the thickness of this coat, together with its transparency, allows of no particular surface for receiving the image; and that its transparency would cause a partial dispersion, which would produce a confusion in vision.*

If these opinions require serious refutation, we have it in the effects of the diseases of the retina, optic nerve, and brain. But the thalami nervorum, the optic nerve, and its expansion into the retina, seem scarcely to have ever occurred to these speculators, as worthy of notice in this investigation.

The following appears to me the true account of this matter. It is demonstrated, that the inner surface of the retina is a web of membrane conveying vessels, and that the outer surface of the retina consists of the pulpy-like nervous matter. This latter, then, is the organized surface adapted to receive the impression of the rays of light. At the point where the optic nerve comes through the coats of the eye, there is no posterior surface peculiarly adapted to receive the impression of light; and, as well might we expect the optic nerve to be sensible to the impression of light in any point of its extent from the brain to the eye, as at this; for here the inner surface of the retina only is formed; there is no posterior surface upon which the rays can impinge. The doubts regarding the cause of this spot giving no sensation, have arisen from the idea, that the internal surface of the retina, or its substance, felt the impression of the rays of light.

At the same time, it is evident, that the choroid coat, and its secretion, is in a most remarkable manner subservient to the retina, as the instrument of vision: for, when the secretion is black, it absorbs the rays; and animals which have such a pigmentum nigrum, see best during the full day: again, when the surface is of a shining nature, it repels the rays, and this contributes to strengthen the sensation; and such animals are fitted for seeing in obscure light: nay, further, if the surface of the choroid be coloured, the animal will see objects of that colour the best, because the colour of the choroid depends upon its

* M. Le Cat thought that the pia mater was the sentient part of the nerve. It was, therefore, a kind of confirmation of his opinion to suppose the choroid to be the seat of vision, as he teaches that the choroid coat is a production of the pia mater. He conceived that the retina moderated the impression of light upon the choroid coat, as the cuticle dulls the impression on the papillæ of the tongue.

reflecting more of the coloured ray, than of the others of which light is composed.

But as animals see which have no paint on the choroid, neither such as will absorb, nor such as will strongly reflect the rays, and which have merely the surface of the choroid with its coloured blood-vessels in contact with the retina; so, it is evident, that it is not the deficiency of the chōroid coat, nor the want of the black paint at the entrance of the optic nerve, which prevents the sensation; but really, that there is here no surface formed and organized to receive the impression of the light; the outer surface not being the sensible surface of the retina.



FURTHER OBSERVATIONS ON THE RETINA.

It has already been observed, that vision is the combined operation of the organ, nerve, and brain; consequently, the destruction of the function may be produced by disease of the retina, of the optic nerve, or of the brain. Disease in the retina, nerve, or corresponding part of the brain, causing total blindness, while the cornea and humours of the eye remain pellucid, is called AMAUROSIS. It is, in general, to be considered as a paralytic affection. Amaurosis* has been found to follow strokes on the head; concussion and compression of the brain; blood effused within the skull; or tumours pressing on the nerve or brain.† An amaurosis spasmodica has been enumerated by authors. This kind of blindness has been supposed to arise in consequence of the stricture of the optic nerve by the origins of the recti muscles; as far as I have observed, no action of these muscles can affect the optic nerve before it perforates the coats of the eye. If it were to be attributed to the operation of these muscles, I should rather suppose it to

* AMAUROSIS; GUTTA SERENA; CATARACTA NIGRA; which last name is from the blackness of the pupil in consequence of the transparency of the lens.

† “Ipse vidi bis in puerulis scrophulosis amaurosin, etiam subito ingruentem; secto cadavere inveni glandulam strumofam nervis opticis incumbentem.” *Saurages Nosol.* From many observations, we find that tumours and extravasations, which must compress gradually, do yet produce an instantaneous effect.

In Bonetus,* we have many cases of blindness from abscess in the anterior part of the brain; from fluid on the surface, and in the ventricles; from steatomatous tumours; from coagulum of blood, and from a hydatid pressing on the union of the optic nerves; and, lastly, from a calculus in the optic nerve. Blindness from pressure upon the eye and its displacement, and consequent elongation of the optic nerve by an encysted tumour in the orbit, with gradual recovery after operations. See Med. Ob. and Inquir. vol. iv. p. 371.

* De Ocul. Affectibus, Ob. 2.

be occasioned by their spasmodic action on the ball of the eye, by which the function of the retina might be disordered ; but I think it is more probable that the same irritation which is acting on the motatory nerves of the eye, does, in this instance, affect also the optic nerve and retina. However, distention of the coats of the eye, by increased secretion of the humours, destroys the sensibility of the retina. In the *hydropthalmia*, there is in the beginning a short-sightedness, so that objects are seen only when near the eye. Thus far we might account for the defect of vision by the alteration of the focus of the cornea and humours ; but, bye and bye, as the eye enlarges, as it becomes turgid, and the coats more distended, the pupil becomes stationary, and the vision is lost before the aqueous humour has become turbid.*

The connexion and sympathy betwixt the retina and the viscera of the abdomen is sometimes very particular : I have seen frequently a proof of this in the disorder of the stomach having an immediate effect on the sensibility of the retina. Allied to this, but greater in degree, is the *amaurosis* which attacks hysterical women suddenly with head-ach and violent pain. From such sympathy of parts arise the *amaurosis biliosa*, *verminosa intermittens*, *arthritica*, &c. Such attacks of blindness have been found to alternate with convulsions.†

The *amaurosis* is a total blindness, while there is a transparency of the humours and coats of the eye. *AMBLYOPIA* is, on the contrary, only a partial privation of sight, with a pellucid state of the eye.

Commencing cataracts and opacities of the cornea, and of the humours in general, give occasion to spots and obscurities in the vision ;‡ but we have at present to consider those only

* To complete such a case, we may further observe, that there is now an accession of pain, a tension over the forehead and pericrania, and there is sometimes accompanying it a swelling and insensibility of the side of the face. So luxation or displacement of the eye, by tumours, causes blindness, by extending the optic nerve or compressing the eye-ball and consequently the retina.

† The following is an ingenious account of the manner in which this may be produced, though to me it is not satisfactory :—" Non infrequens cæcitas post convulsionem graves et frequentes, sed a nemine quod sciam recte descripta causa ; hanc non ab humoris affluxu deduco, ut voluerunt, sed quia in magnis illis per paroxysmas convulsionum partium omnium, et oculorum simul contorsionibus in quibus sæpe quoque convulsi, admodumque exerti et inflexi apparent, attractio sic nimium et tenso nervo optico, illis adnato illoque simul contorto et læso, spiritusque visorii transitu impedito, oculos visione privari contingit, atque inde provenire diligente examine & consideratione invenimus." Platerus Prax. lib. i. c. 7.

‡ *CALIGO* is an obscurity in the vision, depending on obstruction to the rays, from opacities before the pupil. "CATARACTA opacitas est ultra pupillam."—*AMBLYOPIA* and *AMAUROSIS* are occasioned by the disease of the nerve, or confusion from the focal powers of the humours without opacity of any part. But Cullen extends the genus *CALIGO* to all obscurities caused by opacity : he introdu-

which depend on the state of the nerve*. Errors of vision are not easily to be distinguished from those of the imagination proceeding from the brain. Error opticus, or Hallucinatio, from delirium: one distinction of the former is, that we can correct the deception by the assistance of the other senses, while, in the latter, the mind is diseased.

Old people are often troubled with the appearance of dark irregular spots flying before their eyes. In fever, also, it is very common to see the patient picking the bed-clothes; or catching at the empty air. This proceeds from an appearance of motes or flies passing before the eyes, and is occasioned by an affection of the retina, producing in it a sensation similar to that produced by the impression of images; and what is deficient in the sensation, the imagination supplies; for, although the resemblance betwixt those diseased affections of the retina and the idea conveyed to the brain may be very remote, yet, by that slight resemblance, the idea, usually associated with the sensation, will be excited in the mind.

M. de la Hire attributed the fixed spots to drops of extravasated blood on the retina, and the flying ones, to motes in the aqueous humours; † but we shall show presently, that this apparent motion of the motes before the eyes may be a deception. After turning round upon the heel for some time, objects apparently continue in motion. Dr. Porterfield supposed this to proceed from a mistake with respect to the eye, which, though it be at rest, we conceive to move the contrary way to that in which it moved before; from which mistake, with respect to the motion of the eye, the objects at rest will appear to move the same way the objects are imagined to move, and, consequently, will seem to continue their motion for some time after the eye is at rest. How superior is simple experiment to the most ingenious speculation! Dr. Porterfield is presuming in all this, that the eye is at rest when the body is stationary, after turning round rapidly on one foot.—

ces the words “ob repagulum opacum, inter objecta & retinam,” while Sauvage has the expression “repagulum opacum citra pupillam.”

* PSEUDOBLOPSIS is thus defined by Dr. Cullen: “Vifus depravatus ita ut quæ non existant homo se videre imaginatur vel quæ existunt aliter videt ac vera se habeant”—under this genus is SUFFUSIO, PHANTASMA. Under this definition all deceptions from refraction of the rays are naturally comprehended, as well as from the imagination simply: a definition comprehending defects of vision which proceed from causes so very distinct, is an obstruction to the knowledge of diseases. Sauvage has it classed with the vesaniæ, viz. G. suffusio, hallucinatio visus circa objecta.

† “Guttula cruoris retinæ insidens et nigricans, omnem lucem interceptet unde phantasma obscurum vel nigrum; verum si dilutus cruor radios rubros transmittat tunc maculam rubram videbit æger ut omnia trans vitrum inspecta rubra sunt.” Sauvage, vol. iv. p. 287.

But the fact is, that the eyes continue in motion after the body is at rest, but owing to a disorder in the system of sensation we are not sensible of it. Dr. Wells, in making an experiment, in which it was necessary to look upon a luminous body, was seized with giddiness, and he found, that the spot on the retina, affected by the great excitement of the luminous body, did not remain stationary, but, when made apparent by looking upon the wall or any plane, was moved in a manner altogether different from what he conceived to be the direction of his eyes. In making the experiment after looking some time at a candle, and then turning himself round till he became giddy, he afterwards directed his eyes to the middle of a sheet of paper, he saw the dark spot (caused by the former brilliancy of the candle on the retina) take a course over the paper, although he conceived that the position of his eyes remained stationary.— He then directed a person to repeat this experiment, and then bade him look steadfastly to him, and keep his eyes fixed; but instead of keeping stationary, his eyes were seen to move in their sockets; though, of this, the person himself was quite insensible.

From these experiments, we may conclude, that spots which seem to move before the eyes are not, on that account, solely to be attributed to opacity of the humours or cornea, since the appearance of motion may be given to those motes, though occasioned by an affection of the nerve; especially, if the unusual sensation be attended with giddiness. Giddiness, however, is not necessary to such sensation; when my eyes are fatigued, and, sitting in my room, I look towards the window, I see before me small lucid circles which seem to descend in quick succession; upon attending more particularly to my eyes, I find them in perpetual motion; my eye is turned gradually downward, which gives to the spectrum the appearance of descending: but it regains its former elevation with a quick and imperceptible motion. During the slow inclination of the eye downward, the motes or little rings seem to descend; but in lifting the eye again, the motion is so quick, that they are not perceived.*

* The following quotation refers to this sensation:—"Aeger in magna luce constitutus, ut plurimum presbyta, vel oculis nitidissimis gaudens, continuo præ oculis observari sibi putat puncta lucida, quæ non huc et illuc volitant, nec a commoto capite agitantur, ut putat la Hire, et ejus in hoc exscripto Boerhaave; sed constanter si oculus immobilis remaneat, deorsum lentissime delabi videntur; adeoque veluti pluvia aurea præ oculis eaque densa cernitur; quæ verticaliter semper descendit in quacumque capitis positura, sive erecta, sive lateraliter inclinata; hoc in me ipso expertus per annos, observavi in aliis, potissimum illis qui studio nocturno indulserant, et in aegrotante, qui de eo symptomate ad melancholiam fere per multos annos sollicitus erat." Sauvages. This appearance has been at-

There is a kind of umbræ seen before the eyes which are occasioned by the vessels of the retina. Of this kind is the *suffusio reticularis* of Sauvages, in which the person sees umbrageous ramifications which strike across the sphere of vision, and are synchronous with the pulse, showing its dependence on the full and throbbing pulsation of the head. There are also *corruscations* seen before the eyes in consequence of a blow upon the eye ball, and accompanying violent head-ach, vertigo, phrenitis, epilepsy, &c. Whatever forces the blood with great violence to the head, as coughing, vomiting, sneezing, will cause, for the instant, such *corruscations*, by means of the disturbed circulation through the retina.

We are particularly called upon to attend to the connection betwixt the iris and the retina. In *amaurosis*, the sensibility of the retina being entirely lost, the pupil is consequently immoveable and dilated*. But we must recollect, that if one eye be sound, the pupil of the diseased eye follows, in some degree, the movement of the iris of the sound eye. If one eye be shut, the pupil of the other eye will dilate; if the hand be put over the eye-lids of the shut eye, the pupil will still further dilate†.

We find several instances of vision indistinct during full daylight, and perfect in the *crepusculum*. This we have explained by the dilatation of the pupil allowing the rays of light to pass the partial opacity of the lens; it, of course, has no connection with the disease of the retina.

There are also instances of vision being more than naturally obscure in the twilight, which is owing to a degree of insensibility‡. The night blindness, however, is not to be entirely at-

tempted to be explained upon the supposition of a very sensible state of the retina, which perceives the gutulæ exuding from the pores of the cornea, and which, falling over its surface, gives the appearance of their descending. But it is only felt when the retina is exhausted or disturbed by pressure on the eye-ball. See Sauvages *Suffusio Scintillans* & *Suff. Danaës*.

* There are, however, cases of *AMAUROSIS A MYOSI*, in which there is a contracted and immoveable pupil, and children are born with an insensibility of the organ in which the pupil is not greatly dilated. I would be willing to attribute this peculiarity of the pupil and apparent *amaurosis* in newly-born children to the remains of the *membrana pupillaris*.

† The sympathy of the iris with the retina I do not conceive to be immediate, but through the intervention of the brain; and the degree of dilatation of the pupil, I should hold to depend on the strength of the common sensation of both eyes. By this only can we account for the sensibility of the retina of one eye affecting the iris of the other, or the disturbance of the brain, in comatose diseases, destroying the sympathetic connexion betwixt the retina and pupil.

‡ *Est immanis differentia inter splendorem et activitatem luminis candelæ et lunæ: luminis solaris vis est ad vim luminis candelæ 16 pedes distantis, observante D. Bonguer ut 11664 ad 1; et ad lumen lunæ in pleni lunio, ut 374000 ad 1 de-*

tributed to a degree of continued insensibility in the nerve.—The attacks are irregular, and allied to the intermitting amaurosis. It has been epidemic, and the following cases seem to ally it with the paralytic affections.

CASE I. OF NYCTALOPIA, OR NIGHT-BLINDNESS, BY DR. HEBERDEN.

A man, about 30 years old, had, in the spring, a certain fever, for which he took too small a quantity of bark, so that the returns of it were weakened without being entirely removed; he therefore went into the cold bath, and after bathing twice, he felt no more of his fever. Three days after his last fit, being then employed on board of a ship, in the river, he observed, at sun-setting, that all objects began to look blue, which blueness gradually thickened into a cloud, and not long after he became so blind as hardly to perceive the light of a candle. The next morning, about sun-rise, his sight was restored as perfectly as ever. When the next night came on, he lost his sight again in the same manner; and this continued for 12 days and nights. He then came ashore, where the disorder of his eyes gradually abated, and in three days was entirely gone. A month after, he went on board of another ship, and after three days stay in it the night-blindness returned as before, and lasted all the time of his remaining in the ship, which was nine nights. He then left the ship, and his blindness did not return while he was upon land. Some little time afterwards, he went into another ship, in which he continued ten days, during which time the blindness returned only two nights, and never afterwards.

In the August following, he complained of loss of appetite, weakness, shortness of breath, and a cough; he fell away very fast, had frequent shiverings, pains in his loins, dysury, and vomitings; all which complaints increased upon him till the middle of November, when he died. He had formerly been employed in lead-works, and had twice lost the use of his hands, as is usual among the workers in this metal. Medical Transactions, published by the College of Physicians in London, vol. i. p. 60.

monstrante D. Euler Mem. de l'Acad. de Berlin, an 1750, pag. 299. non mirum itaque si vis toties major sufficeret ad succutiendam retinam quam tanto minor non afficiebat. *Savage's Amblyopia Crepuscularis.*

CASE II. OF NYCTALOPIA, BY DR. SAMUEL PYE.

Pye, servant to a miller, at the 6th mill, on the Lime-house wall, about 40 years of age, came to me October 2d, 1754, for advice and assistance. He told me, that about two months ago, while he was employed in mending some sacks, near the setting of the sun, he was suddenly deprived of *the use of his limbs* and of his sight. At the time he was attacked with this extraordinary disease, he was not only free from any pain in his head or his limbs, but, on the contrary, had a sensation of ease and pleasure; he was, as he expressed himself, as if in a pleasing dose; but perfectly sensible. He was immediately carried to bed, and watched till midnight; at which time he desired those who attended him, to leave him, because he was neither sick nor in pain. He continued the whole night totally blind and without a wink of sleep.

When the day-light of the next morning appeared, his sight returned to him gradually as the light of the sun increased, till it became as perfect as ever; when he rose from bed, his limbs were restored to their usual strength and usefulness, and himself in perfect health.

But on the evening of the same day, about the setting of the sun, he began to see but obscurely, and his sight gradually departed from him, and he became as blind as on the preceding night; though his limbs continued as well as in perfect health; nor had he, from the first night, any complaint from that quarter.

The next day, with the rising sun, his sight returned; and this has been the almost constant course of his disease for two months past. From the second night, the symptoms preceding the darkness were a slight pain over the eyes, and a noise in his head, which he compared to a squashing of water in his ears.

After near two months continuance of the disease, on September the 29th, the patient was able to see all night; on the 30th September, October 1 and 2, he was again blind all night; on the 3d, he was able to see; on the 4th, he was blind till 12; on the 5th was blind. From this he had no return of his complaint till June 1755; from which time till the 3d of October, when I again saw him, he had three or four attacks; from the 3d till the 10th, he had an attack every evening.—He had at this time a purging. I ordered him an electuary of bark and nutmeg, which succeeded in removing the blindness, but the diarrhœa continued wasting him. On the 20th, deliri-

um came on ; on the 21st, he became deaf ; he died on the 25th, after having suffered from fever, pain in his bowels, and continued diarrhœa ; but the defect in his eyes never returned after the 10th. This man had clear bright eyes : when his sight failed him the pupils were enlarged about one-third in diameter. *Medical Facts and Inquiries*, vol. i. p. 111.

Boerhaave gives us an example of imperfect vision, from a discordance betwixt the contraction of the iris and the excitement of the retina ; so that the pupil did not dilate in proportion to the decay of light.*

When inflammation extends within the eye, or when the retina is excited by sympathy with the ophthalmia of the outer membranes, it may happen that the patient is totally blind during the day, and yet sees on the approach of evening ; because, from the sensibility of the retina, the pupil is absolutely shut, but as the light is diminished the pupil is gradually relaxed, and the obscure light admitted, and this obscure light, from the irritable state of the retina, gives a vivid sensation incomprehensible to the by-standers. Our judgments of the strength of sensations are comparative merely ; when we have been accustomed to strong impressions, lesser ones are disregarded. The greater light destroys the capacity of the retina for receiving slighter and more delicate impressions ; while, on the other hand, the absence of light reserves to us the power of seeing objects the most faintly illuminated. We are every day becoming more acquainted with the invisible properties of light ; and we have frequent experience of darkness being relative, and that what we should call total darkness is very often but a fainter light. One man will see distinctly, when another is quite deprived of the power of discerning objects. A man in prison seems to have the light gradually admitted to him ; and many animals are in quick pursuit of their prey, while we are groping our way with the assistance of our other senses.

Animals which seek their prey in a light which is darkness to us, have, most probably, a greater degree of sensibility of the retina. But they have also a more conspicuous apparatus in the largeness of their eyes, and the dilatibility of their pupil, while the sensibility which this provision gives, is often guarded from the light of day by the *membrana nictitans*, and by an iris capable of great contraction. Their iris possesses also a great power of contraction in narrowing the pupil during the day, as it is capable of dilating during the night, to the

* In old people there is an obscurity of vision, from a diminished sensibility of the retina ; and the iris does not take a quick succession of contraction and dilatation with the change of light.

whole extent of the cornea. In the human eye, also, the strict sympathy between the iris and retina is a guard to the latter. But it has often happened that, in using optical instruments, the retina has been hurt by the intensity of the light from the concentrated rays: a lesser degree of this effect we have given us in the following instance.*

“Being occupied in making an exact meridian, in order to observe the transit of Venus, I rashly directed to the sun, by my right eye, the cross hairs of a small telescope. I had often done the like in my younger days with impunity; but I suffered by it at last, which I mention as a warning to others. I soon observed a remarkable dimness in that eye, and for many weeks, when I was in the dark, or shut my eyes, there appeared before the right eye a lucid spot, which trembled much like the image of the sun seen by reflection from water. This appearance grew fainter, and less frequent by degrees, so that now there are seldom any remains of it. But some other very sensible effects of this hurt still remain:—For, first, the sight of the right eye continues to be more dim than that of the left; secondly, the nearest limit of distinct vision is more remote in the right eye than in the other, although, before the time mentioned, they were equal in both these respects, as I had found by many trials; but, thirdly, what I chiefly intend to mention is, that a straight line, in some circumstances, appears to the right eye to have a curvature in it. Thus, when I look upon a music book, and, shutting my left eye, direct the right to a point of the middle line of the five which compose the staff of music, the middle line appears dim indeed at the point to which the eye is directed, but straight; at the same time the two lines above it and the two below it appear to be bent outwards, and to be more distinct from each other, and from the middle line than at other parts of the staff to which the eye is not directed. Fourthly, although I have repeated this experiment times innumerable within these 16 months, I do not find that custom and experience take away this appearance of curvature in straight lines. Lastly, this appearance of curvature is perceptible when I look with the right eye only, but not when I look with both eyes; yet I see better with both eyes together than even with the left eye alone.”

Herschel, in making his observations on the sun, found the irritation proceeding from the red rays (being those of the rays of light which have the property of producing heat in the greatest degree;) he found, when he used red glass to intercept the too vivid impression of light on his eyes, that they stopped the

* Viz. by Dr. Reid.

light, but produced an insufferable irritation from the degree of heat. But when he used green glass, it transmitted more light, and remedied the former inconvenience of an irritation arising from heat. He concluded, that in the darkening glasses for telescopes, the red light of the sun should be entirely intercepted. Boerhaave mentions an instance of the retina being injured by the long use of the telescope, and he himself was hurt by a similar cause. These injuries are owing to the intrusion of light highly concentrated, and over which the pupil has no command; it is a degree of intensity which the organ is not prepared to counteract.



CHAP. VI.

OF THE MEMBRANA PUPILLARIS.

THE membrana pupillaris is an extremely vascular membrane, which is extended across the pupil of the fœtus. It was discovered by Haller, Albinus, Wachendorf,* and Dr. William Hunter, at the same time or without correspondence with each other. Haller,† after injecting, with oil of turpentine and cinnabar, a fœtus of the seventh month, saw through the cornea the vessels of the iris injected, and some ramifications from them produced into the space of the pupil. From conviction that no vessels ramified without an involving membrane, he naturally concluded, that a membrane was drawn across the pupil of the fœtus, though, in this instance, it was about to disappear.

In several other fœtuses of the seventh month he confirmed his first observation; and, cutting off the cornea, he observed the membrane impelled forward by the humours behind like a little vesicle.

Albinus, in his first book of *Academical Annotations*, thus describes the way in which he detected this membrane. In the same child in whom he had filled the vessels of the crystal-

* In *Commercio Norico*, A. 1740, hebd. 18. as quoted by Haller.

† *De nova tunica pupillam fœtus claudente*. Oper. minor.

line, he also first observed the membrane which closes the pupil, and in which the vessels were injected that came from the margin of the pupil. Upon looking through the cornea, he could see no distinction of parts, but all seemed vascularity. He conceived, at first, that these were the vessels of the uvea, and that it had quite contracted and had shut the pupil; then that they were the vessels of the capsule of the crystalline lens; but having cut into the eye, he found it to be this membrane. Dr. Hunter, speaking of this membrane, and of Albinus's claim to the discovery, says, "In justice to this great anatomist, I must declare that I believe this, both because he asserts it and because I know from the circumstances it was hardly possible he could miss taking notice of it in that child." "I have always observed (he continues,) both in the human body and in the quadruped, that there is a great resemblance to one another in the vessels of the capsula cristallini and of the membrana pupillæ. In an injected fœtus, I always find both nearly in the same state: if one be filled only with the blood that is drove before the injection, so is the other; if one be filled partly with injection, and partly with blood, the other is in the same condition; if one, by good fortune, be finely and minutely filled by injection, the other is so too; if one be burst by extravasations, the other is commonly in the same state; and when the fœtus is so near its full time that the one cannot be injected, neither can the other."*

Dr. Hunter, speaking further of the artery of the crystalline capsule, says, "that it does not terminate at the great circle of that humour. Its small branches pass that circle, and run a very little way on the anterior surface of the crystalline humour before the points of the ciliary processes; then they leave the humour and run forwards, supported on a very delicate membrane, to lose themselves in the membrana pupillæ." He continues: "The membrana pupillæ receives two different sets of arteries, one larger, from the iris, and the other much smaller, but very numerous from the crystalline capsula."

Now I think that every expression in these excerpts confirms the opinion I entertain, that these vessels which are seen filled with red blood, and which take their course through the humours, are subservient merely to the membrana pupillaris.

The first time I observed the membrana pupillaris was in the eye of a child born at the full time. I had injected the child very minutely with size and vermilion, and the iris was beautifully red and the pupil quite transparent and black, and not obscured by any extravasation of the injection into the aqueous

* See Medical Commentaries, p. 63. foot note.

humour: upon very narrowly observing the circle of the iris, I saw distinctly a small injected vessel pass out from the edge of the iris, and crossing the pupil, divide into two branches which ran into the opposite margin of the iris. This was the remains of the membrane, but so delicate and so perfectly transparent, that the presence of it was only to be argued from the vessel which was seen to cross the pupil.

Since that time I have often seen it in the early months, and particularly strong about the seventh month of the fœtus. It is then an opaque, and very vascular membrane, and generally it has spots and streaks of extravasation in it. The vascular structure of this membrane is very particular, and I can assign no other reason for this than that it may be a provision for its rapid absorption. It has evidently two sources of vessels, viz. the vessels of the capsules and those of the iris; but whether the arteries come by the one source, and the veins depart by the other, I cannot as yet determine. In one preparation I see the vessels with their trunk in the membrana pupillaris, and the branches sent over the surface of the iris.

The larger and flat venous-like vessels of the membrane are distributed in a beautiful net-work, in the form of the lozenge of a Gothic window. They have a free communication with each other. In their whole course the vessels seem nearly of the same size, (which also is like the character of a venous net-work,) and they terminate apparently in the margin of the iris.

The use of the membrana pupillaris I think sufficiently apparent, though I do not find that it has hitherto been understood. Haller makes a comparison betwixt this membrane, which closes up the pupil, and that matter which is accumulated in the passage of the ear in the fœtus. But there is no analogy. As the waters of the amnios might otherwise be in contact with the membrane of the drum of the ear, and injure what necessarily is of a dry and arid nature, to adapt it for receiving the vibrations of the air, this matter accumulated in the ear of the fœtus defends it. But at the time, when the membrana pupillaris exists in its full strength and vascularity, no light is admitted into the eye—the fœtus is lying in its mother's womb. Towards the ninth month, the membrane has become transparent, and if not totally absorbed, it is torn by the first motion of the pupil and altogether disappears. It can therefore have no effect in obscuring the light, and preventing it from exciting in too great a degree the eye of the newly-born child. To explain the effect of this membrane, then, we have only to consider that it is of the nature of the iris to contract its circular fibres during the operation of light, so as to

close or nearly close the pupil; that, on the other hand, the pupil is completely dilated through the operation of the radiated fibres of the iris in darkness:—To the question, then, why it is not dilated during the fœtal state? The answer, I think, is decidedly this:—The iris is not loose in the fœtal state, it is connected and stretched to the middle degree of contraction and dilatation by the membrana pupillaris. Were the iris in a full state of contraction, during the life of the fœtus, it could not receive its full nourishment, proper degree of extension, and due powers; but being preserved stationary and extended, the disposition to contraction, which it must have when the retina is without excitement, is counteracted, until it is about to receive, by the birth of the child, that degree of excitement which is to keep up the preponderance towards the contracted state of the pupil.



CHAP. VII.

OF THE HUMOURS OF THE EYE.



OF THE AQUEOUS HUMOUR.

THE aqueous humour is perfectly limpid. It has no capsule or surrounding membrane, as it is not in consistence allied to the other humours, but is fluid.* The use which I have assigned to the aqueous humour explains its nature and the extent of the chamber which contains it, viz. that it distends the cornea and allows the free motion of the iris; it consequently fills the space between the lens and cornea. The usual description is, that it is lodged in two chambers; the one before the iris, called the anterior chamber of the aqueous humour, and the other behind the iris, called the posterior chamber of the aqueous humour.

* It possesses, however, a degree of viscosity. Winflow.

This posterior chamber was, at one time, conceived to be of great extent,* and authors spoke of depressing the lens into the posterior chamber of the aqueous humour.† It is found, now, that betwixt the lens and iris there is no space to which we ought to give this name of chamber.

Heister, Morgagni, and M. Petit (medecin) first demonstrated the extreme smallness of the posterior chamber, and after them Winslow confirmed the fact, that the iris moved almost in contact with the anterior surface of the lens.

M. Petit gave the clearest proof of the smallness of the posterior chamber, by freezing all the humours of the eye, and dissecting them in their solid state. Without this expedient it was impossible to prove the relative size of the two chambers; for, whenever the cornea was cut, the aqueous fluid escaped, and the lens pushed forward. When the eye was frozen, and then dissected, it was found that the ice, which took the shape and dimensions of the anterior chamber, was much larger than that found in the posterior chamber;‡ indeed the latter was formed of a very thin flake of ice. The thin piece of ice in the posterior chamber indicated as much fluid only betwixt the iris and lens as might allow a free motion to the iris. These experiments were instituted in the course of investigating the question of the nature of the cataract.

The conclusion, that the posterior chamber of the aqueous humour contained but one-fourth of the whole aqueous humour, was admitted with great difficulty and after much contest. It determined the question, whether the cataract was a membrane or the opaque lens; for, as those who maintained that it was a membrane, said it could not be the lens, because the lens was far distant from the iris, it was necessary for their opponents to prove that the lens was close upon the pupil, and that the posterior chamber of the aqueous humour was very small.

It is agreed that, in the adult, the quantity of the aqueous humour amounts to five grains; in the fœtus it is red, turbid, and weighs about a grain and a half, owing, in part, to the comparatively greater thickness of the cornea.

As it is natural to conceive that the aqueous humour flows from a vascular surface, it is the most generally received opinion, that it is derived from the points of the ciliary pro-

* Viz. by Heister. They were called the first and second chambers by M. Bisseau.

† There certainly appears sufficient room for this in Vesalius and Briggs' plates: these plates have misled many.

‡ See Acad. Roy. des Sciences, 1723. Mem. p. 38.

cesses and surface of the iris. Haller, particularly, and after him Zinn, have thought that the ciliary processes were the secreting bodies; but there is one argument which, in my mind, determines that these are not the sole secreting parts, viz. that while the membrana pupillaris closes up the communication betwixt the two chambers, I have observed the anterior one to be full of the fluid, which of course must have been supplied from another source than the ciliary processes. I suppose, therefore, that the villous surface of the iris is the proper secreting surface of the aqueous humour.* Zinn observes, that Haller saw the membrana pupillaris distended and bulged forwards by the aqueous humour in the posterior chamber. It is scarcely necessary to say, that this must always take place when the cornea is first opened in demonstrating that membrane, whether there be a watery fluid behind it or not. But I believe I shall be able to prove, that the secretion of the ciliary processes can have little power of filling the posterior chamber, even from the connexion of membranes behind the membrana pupillaris in the fœtus. The aqueous fluid is perpetually undergoing the change of secretion and absorption, and this is the reason of its quick renewal when it has been allowed to escape by puncture of the cornea. The ancients were not ignorant of the quick regeneration of this fluid. It was proved to the moderns by a charlatan, Josephus Burrhus (*ventosus homo, qui in carcere Romano periit.*) Before the physicians of Amsterdam he punctured the cornea of a dog; then instilling his liquor under the cornea, he bound up the eye; in a few days he took off the bandage, and showed them the cornea again distended with the aqueous humour. It was soon found that the instilled fluid was of no kind of consequence. Redi and Nuck made many experiments, and it was found that the aqueous humour was regenerated in the course of 24 hours.

When the disputes regarding the cataract ran high, and when, to make new distinctions in the disease was taken as a mark of practical knowledge and of acuteness, there was a kind of cataract attributed to the aqueous humour. When the aqueous humour became turbid, white, and opaque, and obscured the pupil, they were absurd enough to call this a

* The opinion of Nuck is now out of the question. He thought that he had discovered particular aqueducts, which conveyed the aqueous humour into the anterior part of the eye; but these are found to be nothing more than the short ciliary arteries which pierce the fore part of the sclerotica. M. Merry and Bonhomme, (see Zinn, p. 143) observed, in an adult, the pupil closed with a membrane, and, in this instance, there was scarcely any fluid in the anterior chamber, whilst the posterior was turgid with fluid.

cataract. The turbid state of the aqueous humour is at once distinguishable from the opaque lens, because it obscures the iris as well as the pupil.

Pus is formed in the chambers of the aqueous humour, in consequence of deep inflammation, contusions, &c. and from the same cause, sometimes, proceeds a bloody effusion. When the pus has lodged in the anterior chamber of the aqueous humour, it would appear, upon the authority of Galen, that an oculist of his day performed a cure by shaking the patient's head !* It is an operation of oculists to puncture and allow the pus to flow out, and some have even syringed out the pus with water ;† but this must have been on the principles of Joseph Burrhus's exhibition ; for the natural secretion is here the best diluent. When we recollect the nature of the parts with which the pus lies in contact, we cannot be sanguine in the hope of such an operation saving the eye. Sometimes there remains, after operation on the cornea, or in consequence of ulceration, a continued flow of the aqueous humour ; the consequence is a subsiding of the cornea :‡ it becomes corrugated, opaque, and, from the contact of the iris, apt to adhere to the iris. In consequence of this suppuration, there sometimes follows an absolute obstruction of the pupil, from the coalescing and adhesion of the edges of the iris.§

THE VITREOUS HUMOUR.

The vitreous humour, as already explained, occupies almost entirely the great ball of the eye. It is consequently beyond the lens, and keeps it at the requisite distance, to cause the rays from objects to concentrate and impinge upon the retina. The vitreous humour is considerably denser than the aqueous humour ;|| but its peculiar appearance, its glairy-like consistence, is not owing to its density, but to the manner in which it is contained in its membranes. From being contained in a cellular structure of perfectly pellucid membranes, it has the adhesion and consistence of the white of an egg. This mem-

* Mouchart says, he has often seen the oculist Woolhouse repeat this cure by shaking his patient's head over the side of the bed. He attributed the cure to the falling of the pus into the posterior chamber, which, he supposes, has parts more capable of absorbing it.

† They were at variance regarding the place at which to puncture for this discharge :—Some did it behind the iris ; there we know there is a crowd of vessels ; the best place is the lower edge of the cornea before the iris. It seems to have been no uncommon accident, in this operation, to find the lens protruded through the pupil. The reason of this has been already explained.

‡ Rhytidosis, seu subfidentia & corrugatio corneæ.

§ Viz. Synifesis. There has occurred congenital imperforation of the pupil.

|| It is, according to Dr. Monro, in the proportion of as 1016 to 1000.

branous structure of the vitreous humour has been demonstrated by acids and by freezing. When frozen, it was found to consist of pieces of ice connected by strong membranes, which separated with difficulty, and showed their torn fragments; and M. Demours lifted the transparent membranes with the point of a needle. Although the vitreous humour appears to be gelatinous, it is not so in reality, and when it is taken from the coats of the eye, it retains the shape for a time, but gradually subsides by the fluid exuding from the membranes, and this is accelerated by puncturing it.

OF THE CRYSTALLINE LENS.

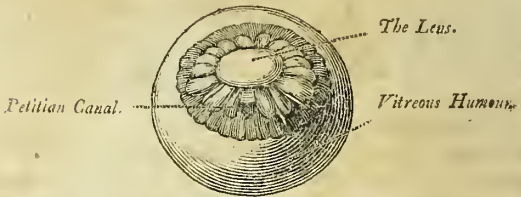
The crystalline humour is a small body, of the shape of an optician's lens, of great power. It is of perfect transparency, and of density much greater than the vitreous humour. Its density to that of the vitreous humour is calculated to be as 1114 to 1016. But the crystalline is not of uniform density, for the centre forms a denser nucleus.

The form of the crystalline is that of a compressed sphere, the anterior surface being more compressed or flatter, though, in a degree, convex. According to Petit, the anterior surface is the segment of a sphere whose diameter is 7, 8, or even nine lines. The posterior surface is a sphere of 4 3-4 or 5, or 5 1-2 lines in diameter. The internal structure of the lens is quite peculiar, and resembles neither the vitreous nor the aqueous humour. By maceration, it splits into lamellæ, and at the same time bursts up into equal parts, so that there is first a stellated-like fissure, and then it separates into pretty regular divisions; and after maceration in acids, the lens can be teased out into minute shreds and fibres.*

From its form, density, and central nucleus, it has great power of converging the rays of light; and in an eye properly constituted, it concentrates them accurately to the surface of the retina. For this reason, it is placed before the vitreous humour, and socketed in its anterior part. It is contained in a capsular membrane, which membrane is continued from, or connected with, the membranes of the vitreous humour: but this is a subject which requires a more particular investigation.

* See further of the muscularity of the lens.

OF THE CAPSULE OF THE LENS AND VITREOUS HUMOUR.

*Marg. Plate, 13.**Fig. 2.**Fig. 3.**Fig. 1.*

In fig. 1. we have the appearance of the petitian canal blown up. It is not found full of any fluid, it is only the laminæ of membrane inflated, and it is best demonstrated by cutting off the cornea, and with it a small circular portion of the sclerotica, and taking with these the iris also, when the lens presents itself seated firmly in its capsule on the vitreous humour. Now laying back the ciliary processes, we make a fine puncture with a lancet by the side of the lens, and then blow gently into it with the blow-pipe.

Every anatomist acknowledges the existence of the petitian canal, and a distinct capsule to the lens is also pretty generally allowed. But many deny that the vitreous membrane has two plates, without observing that the existence of the petitian canal is a proof of the splitting of the membrana vitrea, on the fore part at least. Some believe that the vitreous membrane splits and involves the lens, and forms its capsule; but the difficulty, on this supposition, is still to account for the formation of the canal which surrounds the lens; for as the fluids on the surface of the lens and within its capsule have not admission to the canal, the canal must be distinct; and, indeed, sometimes we blow up the circular canal, and sometimes by

a wrong puncture, the capsule of the lens itself ; but not both at once.

Seeing, then, that these cavities are distinct, some anatomists have admitted that the *membrana vitrea* is double ; that the lens has its proper capsule ; and that the lamina of the vitreous membrane, coming near the margin of the lens, splits and involves it in a second coat, (as in fig. 2.) Others have supposed that the anterior layer of the vitreous humour does not pass over the anterior surface of the proper capsule of the lens, but only adheres to the edge of the capsule of the lens, and forms the petitian canal. There are yet others who have described the *membrana vasculosa* of the retina as forming the capsule of the lens. This is one of those pieces of anatomy which provokes us to continued research, and mortifies us with continual disappointment. If this piece of anatomy, when investigated in the eye of an adult, is difficult to be understood, it is infinitely more complicated in the eye of the fœtus ; and, for my own part, I cannot reconcile my experience with any former opinion.

I conceive that it is the *membrana vasculosa tunicæ retinæ*, or *membrana vasculosa ruyschii*, which forms the vascular capsule of the lens in the fœtus, and also the canal of Petit in the adult. The crystalline lens has, in the first place, its proper capsule, which surrounds it on all sides : again, the transparent web of membrane that is continued onward from that part of the retina which has upon it the pulpy and nervous expansion, splits when it approaches the margin of the lens.— One lamina goes round behind the lens, and the other passes a little before it, forms an adhesion to the capsule of the lens, and is then reflected off to the points of the ciliary processes and to the *membrana pupillaris* of the fœtus.* Betwixt these split laminae of the continued membrane of the retina, the canal, which surrounds the lens, is formed. The *membrana vitrea* is simply reflected over the back of the lens, and has no part in forming the petitian canal. Where the retina advances forward upon the ciliary processes, it forms an adhesion, beyond which the medullary part is not continued ; but the *membrana vasculosa* passing onward, as I have described, embraces the lens, and the lamina, which passes behind the lens and before

* In the fœtus, as far as I have observed, the proper capsule of the lens and the *membrana pupillaris* lie in contact, but they do not adhere ; and while the *membrana pupillaris* is perfectly red with injection, there is none to be seen on the fore part of the capsule. There is, indeed, no part of that surface which is afterwards to secrete the aqueous humour, which could secrete that fluid, betwixt the surface of the lens and *membrana pupillaris* : so complete is the adhesion of the adventitious and vascular tunic of the lens to the *membrana pupillaris*.

the vitreous humour, receives and conveys the artery of the capsule; on the fore part of the lens the anterior lamina only touches the capsule of the lens, adheres and is then reflected off to form the *membrana pupillaris*.

In this account I am supported by the most careful investigation, and by the simplicity of this system of vessels: for it will be observed, that it is on the *membrana vasculosa* alone that the vessels, carrying red blood in the fœtus, are supported, and that it shows throughout the same character for vascularity. Again, I think it probable that this membrane which passes before the lens, viz. the *membrana pupillaris*, and that which passes behind the lens, forming the vascular capsule of the lens, disappears at the same time; or if this posterior and vascular membrane which passes behind the lens is not totally absorbed, it becomes thin and more intimately united to the *membrana vitrea*.



CHAP. VIII.

OF THE DISTRIBUTION OF THE CENTRAL ARTERY AND VEIN OF THE RETINA.

I AM the more anxious to give the accurate distribution of these vessels, that Walter's account of them has tended much to derange that simple and natural view of this system which observation authorizes us to take.

The *arteria centralis retinæ* arises from the ophthalmic artery.* Sometimes it is derived from the ciliary arteries before they enter the coats of the eye, and often there is more than one branch entering the optic nerve.† Arising from this source, there are many branches which are distributed to the retina, while a branch passes onward from the *lamina cribrosa* through the vitreous humour to the capsule of the lens. This vessel does not pass exactly in the centre of the vitreous hu-

* See Haller, Fascic. vii. tab. vi. fig. 2. 4. 7.

† Haller, F. vii. p. 42.

mour, but to one side of the axis of the eye. When it arrives near the capsule of the lens, it divides into three or four branches, which, reaching the capsule, spread beautifully on the back part of it.*

The BRANCHES of the arteria centralis retinæ, which are distributed in the retina, are subservient to its support, and are consequently as visible in the adult as in the fœtus; and, where the membrane of the retina has been described as adhering to the point of the ciliary body, these vessels of the retina unite to, or inosculate with the vessels of the ciliary processes.

Walter objects to the description of the arteria centralis retinæ given by Haller and others; he says, decidedly, that there are no arteries distributed to the retina, and that anatomists have deceived themselves in supposing those vessels which ramify on the retina, to be arteries, when, in reality, they are veins; he conceives, that the free return of the injection from the extremities of the arteries into the veins has misled them.

I am at a loss to conceive what notions professor Walter can have entertained regarding this vein distributed in the retina, without an accompanying artery. It is a supposition contrary to the general frame of the œconomy, and I would oppose to it, with confidence, my own experience, since, in the ox and other animals, I have seen the veins of the retina turgid with blood and exceedingly distinct; yet when I injected the trunk of the artery at the root of the optic nerve, I found a set of vessels injected on the surface of the retina quite distinct from the turgid veins, and which could be no other than the arteries distributed to the retina. I must conclude that there is no peculiarity in the distribution of vessels in the tunica vasculosa retinæ.

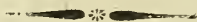
We frequently observe, that the trunks of veins and arteries, destined to the same final distribution, take a different course; but in their final distribution, I know no instance in which they do not ramify with parallel branches interwoven with each other.

THE VENA CENTRALIS RETINÆ, as it is described by Haller, is sometimes a branch of the ophthalmica cerebrialis, but often it rises from the cavernous sinus, amongst the origins of the external and inferior recti muscles of the eye; after giving off

* Walter (de venis oculi) says, the arteria centralis retinæ, having perforated the membrana hyaloidea, passes through the middle of the vitreous humour, and scatters some twigs on the small cells of the vitreous humour. It does not, he says, run through the vitreous humour in a straight line from behind, forward, nor does it divide into a great number of branches in the posterior part of the capsule of the lens, like radii from a centre, as Zinn has described. He asserts that the lens receives its vessels from the investiture of the membrana hyaloidea, and that they run back from the edge of the lens towards the posterior convexity.

many small twigs to the periosteum and fat of the orbit, it passes obliquely from behind, forward, and inward, perforates the sheath of the optic nerve, and, after supplying the sheath, dips into the surface of the nerve.—It is now the comes arteriæ centralis retinæ. It enters through the cribriform plate of the optic nerve, and spreading generally in large and remarkable branches on the retina, these make free inosculations with each other, and finally inosculate with the veins of the ciliary processes.

Whether a branch of the vena centralis retinæ is sent off to accompany the branch of the artery which takes its course through the vitreous humour, I have not been able to determine.



CHAP. IX.

OF THE VASCULARITY OF THE PELLUCID MEMBRANES.

IF we cut through the sclerotic and choroid coat, round the optic nerve as it enters the eye, and afterwards cut up the outer coats towards the cornea, the humours fall out from these coats, and will remain suspended in a fluid, hanging by the optic nerve and closely embraced by the retina: we have now to review these parts taken collectively, independent of the outward and proper coats, and, as I have classed them, as constituting the internal globe of the eye.

The first peculiarity which strikes us here is the perfect transparency of all the parts within the embrace of the retina. As there are, in the adult and healthy eye, no vessels to be seen in the transparent membrane and humours, it becomes a question, whether nature has provided for the support and nourishment of those parts by other means than the common circulation of red blood through vessels? Now, I am inclined to think, that there is no such circulation through them; and I believe, that this would be much more generally allowed, were there not something like a proof remaining in men's minds that these humours and tunics were supplied with red blood in the fœtus: whence they deduce the natural conse-

quence that, in the adult state, these vessels are only shrunk so as to convey only colourless fluids. I have, therefore, in the first place, to give my reasons why I think that these vessels of the fœtus are not subservient to the humours; and, I think, I shall prove that, when they have once disappeared, they are no longer pervious vessels; that, though those parts which they are supposed to supply, should become inflamed and vascular in the adult, these vessels which were apparent in the fœtus do not become enlarged; that they do not administer in any way to inflammation and disease, but that a new source is given, and that vessels are formed which were at no former period discernible.

Why should there be red blood transmitted to the pellucid membranes and humours of the fœtus? Why is not that state of circulation, which nourishes and supports the parts in the adult state, sufficient for their growth and the progress to perfection which they undergo in the fœtus? Why is the capsule of the lens only crowded with vessels carrying red blood, while the proof of vessels passing to the cells of the vitreous coat stands upon some very rare and vague assertions, and such as can be naturally explained by the appearance of those vessels which merely pass through the vitreous humour for a different destination?

I believe this is a view which has been little attended to; but, upon the most minute inquiry, and upon examining the preparations of the vascularity of the eye of the fœtus, I can see no vessels, passing into the humours and carrying red blood, which are not finally distributed to the *membrana pupillaris*. When we lay open the eye of a fœtus, after a very minute and successful injection, we see vessels, which all proceed from the centre of the optic nerve, passing through the vitreous humour to the back of the capsule of the lens, viz. the branches of the *arteria centralis retinæ*. This artery divides very often into many branches before it arrives at the capsule of the lens: now, if these be filled with blood, or but partially injected, they have the appearance of being branches distributed to the vitreous humour, and not to the lens. This appearance is still more apt to deceive us when the lens is separated from the vitreous humour, and when the vitreous humour is otherwise disturbed, for then the vessels shrink and seem to terminate in the midst of the vitreous humour. When the injection is perfect there is no such appearance.

On the back of the lens we see a profusion of vessels; but I think I may positively say that these vessels do not penetrate to the lens itself, but are merely on the capsule, and that having made the circuit of the lens, they terminate in the mem-

brana pupillaris and ciliary body. I can observe no villi on the inner surface of the capsule of the lens, nor any appearance of its being a secreting surface, to lead me to suppose that these vessels secrete the lens, as Walter supposes they do; nor, after the most successful injection of the capsule of the lens and of the coats of the eye in general, can I observe the slightest stain of colour in the pellucid state of the lens, nor betwixt its white fibres when it becomes opaque. Nor have I observed, at any time, a single branch of these vessels, which are so profuse on the back of the lens, distributed to the anterior part of the capsule; on the contrary, they all terminate abruptly at that line, a little forward from the utmost verge of the lens, where they are united to the vessels of the membrana pupillaris and ciliary processes. Were these vessels of the capsule provided for the secretion of the lens, or were those vessels the trunks of lesser branches which pierce into the substance of the lens, they would appear also on the fore part of the capsule.

If I am accurate in these observations, we are authorized to deduce this important conclusion:—that these vessels which we see running through the vitreous humour and capsule of the lens, and which are sometimes seen filled with red blood or injected with size and vermilion, are not the vessels of the humours, but vessels in their passage to the membrana pupillaris, and that they disappear totally when that membrane is absorbed. They are injected when the membrana pupillaris is injected; they are more difficult to fill when that membrane is becoming pellucid and tender towards the latter period of gestation; and with the annihilation of the membrane follows the disappearance of the vessels carrying red blood through the transparent humours of the eye.

In confirmation of the total annihilation of these central vessels of the vitreous humour, I have found that, when disease comes upon the lens of the adult, the vessels, which are apparent in consequence of inflammation, do not proceed through the old tract from the centre of the optic nerve and through the vitreous humour to the lens, but that they come from the extremity of the retina and laterally, and thence spread over the back of the lens.

An eye, which I had lately an opportunity of examining, confirmed me in this opinion. I assisted my brother in an operation on the eye, in which, the anterior part being diseased, it was cut away. I had soon an opportunity of retiring and examining the parts with Dr. Monro. I observed then, an opaque spot on the posterior surface of the lens, which was, indeed, in the capsule, and to this spot there came vessels over the margin of the lens from the extremities of the vessels of

the retina ; but, in the vitreous humour, there were no vessels to be seen, nor any branches passing into the lens obliquely from behind, as they do in the fœtus.



CHAP. X.

SOME SURGICAL OBSERVATIONS CONNECTED WITH THE ANATOMY OF THE HUMOURS.

I HAVE already mentioned, as the principle of the operation of extracting the lens, that the simple action of the muscles, surrounding the eye-ball, is sufficient to protrude the lens, if the incision of the cornea be of proper dimensions relative to the size of the lens. No doubt, if there have been thickening inflammation and perhaps preternatural adhesions of the membranes surrounding the lens, the operation will necessarily become more complicated ; the lens will not glide at once over the cheek when the incision of the cornea is completed. But still, I think, we are not to allow ourselves to consider it as a step of the operation, in any circumstances, that the ball of the eye is to be pressed ; because, in that case, the membranes of the lens give way suddenly, and part of the vitreous humour unavoidably is protruded with it, or the edge of the lens is turned obliquely to the pupil, and the vitreous humour escapes by the side of it. It is better to destroy the adhesions with the instrument, and to scratch the capsule of the lens so that it may burst. Whence it is evident that it is necessary, in order to insure the correct performance of the operation of extraction, that the lens should press equally forward on the pupil, and that the pupil should be allowed to dilate. From this it appears, how loose the ideas of those are who can speak of trying first to couch, and if that is not found to succeed, then to perform the operation of extraction. I conceive the attempt with the needle to preclude the operation of extracting, for these reasons :—An unsuccessful attempt to depress will, in general, be a laboured and reiterated motion of the point of the needle, which must occasion inflammation and an adhesion firmer

than is natural. Again, in couching, the lens is removed from the axis of the eye so far only that, in the case of the extracting being attempted, it no longer equally opposes itself to the pupil, the consequence of which must be, the escape of the vitreous humour and the detention of the lens.

In regard to the place at which the couching needle is to be introduced, we may observe, that we are directed, by the older surgeons, to pierce the sclerotic coat very near to the edge of the cornea, because they were afraid of hurting the lens with the needle ! The idea then entertained was, that the cataract was a membrane hung behind the pupil and before the lens.—The older surgeons had the idea that the needle entered before the lens, and passed at once into the aqueous humour. We are to disregard these injunctions of surgeons who directed the needle to be introduced with the idea of avoiding the lens ; for, while their notions regarding the disease were erroneous, their rules of operating could not be correct : accordingly, we find them differing in their directions as to the place of piercing the cornea ; some directing us to pierce it at the distance of one line from the edge of the cornea, others at the distance of four lines and a half.

Now that we know the place of the cataract, and know also that it is the opaque lens, we can be at no loss to introduce the needle correctly. If, says M. Petit, we pierce the sclerotic coat one line from the edge of the cornea, we pierce the tunica conjunctiva, sclerotica, choroid, vitreous humour, and ciliary processes before the needle enters the cataract. In this puncture, we wound the most vascular part, and, indeed, every delicate part of the eye ; for even in this most anterior course, the retina is equally lacerated with the others.* But if we pierce the sclerotic coat, three lines from the edge of the cornea, we avoid the ciliary ligament and body, and processes ; and, by directing it a little forward, in a line towards the opposite margin of the iris, we shall find the point of the needle advancing through the opaque lens ; for, although the lens be so far opaque as to prevent the light from striking the retina, it is so far transparent, in general, that the needle is distinctly seen entering its substance, and can be then directed, so as to transfix the cataract without hurting the iris.

We have seen that there is no posterior chamber of the aqueous humour fit to contain the depressed crystalline lens. The belief, which even some modern surgeons have entertained, of

* In our most modern system of surgery, we are directed to enter the needle one tenth of an inch. To my certain knowledge, not only the ciliary body has been injured by this direction, but even the root of the iris has been seen to be pushed forward on the point of the needle.

the possibility of depressing the lens into the aqueous humour, is a remnant of those inaccurate notions respecting the size of the posterior chamber of the aqueous humour and the place of the lens, which have long been corrected. With this, also, I think ought to have been forgotten, the idea of the rising of the lens after it has been depressed by the cataract floating in the humours.—The fact I am confident is this: when, after transfixing the cataract, we endeavour to dislodge it by depressing the point of the needle, we separate the adhesion between the humours and the points of the ciliary processes; we do not, however, unsocket the lens from the fore part of the vitreous humour, but when the lens descends with the point of the needle, from before the pupil, the vitreous humour revolves with it; the consequence of which is, that when the needle is withdrawn, the lens rolls round with the vitreous humour: but as the lens only is opaque as its firm connexion with the vitreous humour, and even the rolling of the vitreous humour itself cannot be seen, this rolling of the lens appears to be the consequence merely of its own buoyancy in the aqueous humour.—This adhesion of the lens to the vitreous humour, I have been sensible of during its depression, from the elastic nature of the resistance which I felt. When the lens parts from its socket in the vitreous humour, and when it is depressed with such a turn of the needle as puts it under the anterior part of the vitreous humour, it cannot rise again; there is no motion of the eye which can replace it—there is no aqueous fluid in which, if it were of less specific gravity, it could rise: it lies under and, in part, imbedded in the vitreous humour. Another idea is, that it rises with the needle: but no one who understands what is to be done in the operation of the needle, will raise it again opposite to the pupil after the lens is depressed—it ought to be withdrawn without again elevating the point. But what has always appeared to me as the most unaccountable cause that can be assigned for the rising of the cataract, is the action of the muscles of the eye.* It has been explained how the lens is protruded by the action of the muscles when the cornea is cut and the aqueous humour let out, for then the uniform resistance of the eye is broken, and there is a motion of the humours towards the breach, and the lens, lying behind the pupil, is the first part to be protruded forward; but when it lies under the anterior part of the vitreous humour (and there it must lie if it is at all displaced,) or in whatever situation it happens to be, from that it cannot be moved by the action of the recti muscles; for they embrace the eye on every side, and their ac-

* See Mr. Benjamin Bell's System of Surgery.

tion operates uniformly, so that they cannot affect a body immersed in the midst of the humours. For the same reason that we should decline the operation of extracting, after attempts have been made to depress with the needle, I should refuse when the pupil is rugged and irregular, because the disease may be more extensive than it appears to be. Thus cataracts brought on by falls, or blows, or punctures of the eye, are less favourable, as there is danger of the inflammation having gone deep, and having affected the other humours in a way which cannot be known, since the opaque lens is betwixt us and them.

A frequent cause of the failure of the operation of depression is the displacement of the lens backwards; for when it seems to have gone down with the needle, it has slipped from under it and started backward. In this case the pupil appears clear, but the patient gains little advantage; for the cataract, though removed from the pupil, is still in the situation to obstruct the light.



CHAP. XI.

OF THE MANNER IN WHICH THE EYE ADAPTS ITSELF TO THE DISTANCE OF OBJECTS.

THIS is a question which many have endeavoured to determine, and many have failed; the proof of which is, that there is not *one* explanation of the manner in which the eye adapts itself to the distance of objects, but *many* explanations equally ingenious.

One opinion is, that the eye is at rest when we see the distant parts of a landscape, but that the direction of the eye to the nearer objects is attended with an effort. This effort is the action of the straight muscles of the eye compressing the ball of the eye, so as to lengthen the axis as much as is necessary to allow the pencils of rays to unite in points upon the retina.

To this opinion it is objected, that in some animals the sclerotic is hard, and not capable of changing its figure; that in man, the pressure would be unequal; that the unelastic

retina would be thrown into irregular folds ; that these muscles, being voluntary muscles, under the will, we should be more conscious of their operation than we are ; and that, while the mind remains attentive to distant objects, no voluntary exertion of these muscles can affect the distinctness of the objects. Again, to make the eye change its accommodation from the distinct vision of objects, at six inches to fourteen feet five inches, would require such a pressure as might lengthen the axis of the eye one tenth part, which again would form an oval that would derange the retina.

Another opinion is, that when the eye sees the nearest objects it is at rest ; and that, in attending to distant objects, the straight muscles draw back the fore part of the eye into the socket, and thus shorten the axis. To this opinion, of course, the same objections lie as to the supposition that the axis is lengthened by the operation of the muscles.

There are some who have entertained an opinion, that the iris, by its contraction, operates so on the circular margin of the cornea, where it is connected with the sclerotic coat, as to make the cornea more convex, and thus increase its power of concentrating the rays and enable the eye to see near objects distinctly. To account for this power in the iris, Dr. Jurin, the proposer of this hypothesis, supposes that there is a greater muscular ring in the margin of the iris connected with the edge of the cornea : the existence of these muscular fibres is not demonstrated, but he says, since the lesser muscular ring in the inner margin of the iris is not proved by ocular inspection, and yet is justly inferred from its effects, viz. the contraction of the pupil ; in the same way, “ the change of conformation in the eye has not yet been adequately accounted for, but may be fairly made out by supposing the existence of the greater muscular ring.” His conclusion is in these words :—“ When we view objects nearer than the distance of 15 or 16 inches, I suppose the greater muscular ring of the iris contracts, and thereby reduces the cornea to a greater convexity ; and when we cease to view these near objects, this muscular ring ceases to act, and the cornea, by its spring, returns to its usual convexity suited to 15 or 16 inches. In which condition the elasticity of the cornea on the one side, and the tone of the muscular ring on the other, may be considered as two antagonists in a perfect equilibrium.”

To this opinion it is objected, that the iris is not rooted in the cornea, but in the sclerotic coat, which is firm in man and inflexible in many animals. We have also to consider, that this delicate and invisible circle of muscular fibres has not only to contract the margin of the cornea, but, in this action, to

alter the configuration of the whole eye. The eye-ball is a whole equally distended, and no part of it can suffer contraction without a resistance from the whole of the coats: besides, in this case, the alternation of light and the brightness of objects would be perpetually obscuring the image, by the play of the iris causing an alteration of the focus of the cornea. But Dr. Jurin did not attribute the whole effect to the action of the iris. He thus explains the use of the fluid surrounding the lens and the membranous capsule:—When the eye is to be suited to greater distances, he supposed that the ligamentum ciliare contracts its longitudinal fibres, and, by that means, draws the part of the anterior surface of the capsule, into which these fibres are inserted, a little forward and outward. By this action, he supposed that the fluid, within the capsule of the lens, flows from the middle towards the margin; and, consequently, the centre of the capsule of the lens is reduced to a less degree of convexity; and that the elasticity of the capsule, and the tone of the ligament, may be looked upon as two antagonists perfectly in equilibrio with one another. In the state of rest, the eye is conceived, by Dr. Jurin, to be adapted to the middle distance; by the increase of the convexity of the cornea, to be adapted to nearer vision; and by the change in the capsule of the lens, to be fitted to distant objects.

To this last supposition it is objected, that there is a simplicity in the operations of nature; that the change, wrought upon the capsule of the lens, is insufficient to account for the whole effect, and that, therefore, there is a presumption that it has no share in producing the change; that there are no muscular fibres in the ciliary processes; and, lastly, that this fluid, being of density but little, if at all, removed from the aqueous humour, any alteration of its form can have but a very insignificant effect.

It has occurred to others,* that the oblique muscles of the eye-ball, being thrown in opposite directions round it, they may have the effect of elongating the axis of the eye. Again, that the action of the orbicularis muscle of the eye-lids, by compressing the eye-ball, assists in accommodating the eye for seeing near objects more distinctly. Dr. Monro makes a set of experiments to prove the effect of the orbicularis muscle of the eye-lids; but I conceive that he has deceived himself, in ascribing to the compression of the eye-lids an effect partly produced by a voluntary effort, but in a way which is not understood, and partly by the contraction and dilatation

* Hambergerus, Briggs, Keil, Monro.

of the pupil, from the degree of opening of the eye-lids. If he be right in his way of accounting for the effects produced in the experiments which he details, they ought to have the effect of precluding the necessity of all further hypothesis ; so fully does the action of the orbicularis muscle seem to him adapted to the end proposed. In the first experiment, when he opened his eye-lids wide, and endeavoured to read a book the letters on which were so near the eye as to be indistinct, he found that he could not do it. In the second experiment, keeping the head in the same relation to the book, he brought the edges of the eye-lids within a quarter of an inch of each other, and then made an exertion to read, when he found he could see the letters and words distinctly. When I try this experiment, I find the action of the eye-lids to have no sensible effect, unless they are brought very close together : then, I do indeed find that they have a most remarkable effect. But in this situation, the eye-lids cover the cornea so much, that if they have any effect at all upon the cornea, it must be to compress and flatten it, and not to give it a greater convexity. The smaller the opening of the eye-lids, the greater I found the effect. I conceive it to be produced by the optical effect of the eye-lashes correcting the too great converging of the rays ; and the same effect I found to be produced by the marginal hairs of two flat camel-hair brushes, although the eye-lids were kept open. Dr. Monro concludes that, in this action of the eye, 1st, the iris, 2dly, the recti muscles, 3dly, the two oblique muscles, and, 4thly, the orbicularis palpebrarum, have all their share in accommodating it to the distance of objects, and in giving perfect vision.

Very ingenious experiments are made by Dr. Young,* to determine whether there be any change in the length of the axis of the eye-ball. He considers it as necessary, to account for the power of the eye in adapting it to the distance of objects, that the diameter should be enlarged one seventh ; its transverse diameter diminished one fourteenth ; and the semi-diameter shortened one thirtieth of an inch. To determine this he fixed the eye, and at the same time he forced in upon the ball of the eye the ring of a key, so as to cause a phantom very accurately defined to extend within the field of perfect vision ; then looking to bodies at different distances, he expected, if the figure of the eye was altered, that the spot, caused by the pressure, would be altered in shape and dimensions ; he expected that, instead of an increase of the length of the eye's axis, the oval spot caused by the pressure of the key, resisting

* Philos. Transf. for 1801.

this elongation, should have spread over a space at least ten times as large as the most sensible part of the retina : but no such effect took place ; the power of accommodation was as extensive as ever, and there was no perceptible change either in the size or in the figure of the oval spot. Again, he placed two candles so as exactly to answer to the extent of the termination of the optic nerve ; he marked accurately the point to which the eye was directed ; he then made the utmost change in its focal length : expecting that, if there were any elongation of the axis, the external candle would appear to recede outward upon the visible space : but this did not happen ; the apparent place of the obscure part was precisely the same as before.

A favourite opinion of late has been, that the lens has a power of altering its degree of convexity, and thus accommodating itself to the distance of objects. As to the fibrous structure of the lens, there can be no doubt : first it is rent by fissure, then split into lamina, and can be finally teased out into fibres.

This structure was first observed by Leuwenhoeck : he has these words :—“ Porro vidi corpus crystallinum ex tam tenuibus coacervatis constare squamis ut ubi eas oculo dimetior, dicere cogar, plures bis millenis sibi invicem incumbere ; ubi enim corpus crystallinum ab ejus membranula seperassem, ejus adhuc axis, ubi crassissimum erat, (non enim est perfecte rotundum, sed aliquo modo planum) duas tertias pollicis partes retinebat ; ergo a centro ad circumferentiam est tertia pollicis pars atque quoniam, ex dimensione mea, 600 pili lati pollicis quadrati, longitudinem conficiunt 200 pili lati pollicis tertiam partem adæquare debent. Atque nunc video ubi denæ squamæ sunt coacervatæ, eas capilli nostri diametrum nondum adæquare ; ergo his 10 cum 200 multiplicatis, sequetur, ut dictum, plures 2000 squamas in corpore cristallino esse coacervatas.— Porro vidi singulas has squamas ex filamentis, concinno ordine juxta se positas, constare adeo ut singulæ squamulæ unum filamentum sint crassæ ; & ut hanc substantiam fibrosam eam ex qua corpus crystallinum constat ob oculos ponerem, eam, lineis in circulum ductis quantum pote designavi.”

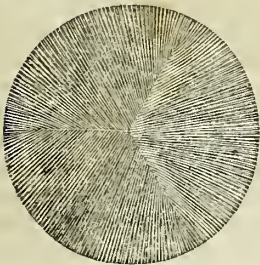
The fibrous structure and muscularity of the lens was brought forward by Descartes, as explaining some actions of the eye ; but was again neglected, till more lately, that it has been revived by the insertion of Mr. Young's observations on vision in the Philosophical Transactions.* The following are Mr. Young's observations on the appearance of the lens :—“ The crystalline lens of the ox is an orbicular convex trans-

* See vol. for 1793.

parent body, composed of a considerable number of similar coats, of which the exterior closely adhere to the interior.— Each of these coats consists of six muscles, intermixed with a gelatinous substance, and attached to six membranous tendons. Three of the tendons are anterior, three posterior; their length is about two thirds of the semi-diameter of the coat; their arrangement is that of three equal and equidistant rays, meeting in the axis of the crystalline; one of the anterior is directed towards the outer angle of the eye, and one of the posterior towards the inner angle, so that the posterior are placed opposite to the middle of the interstices of the anterior; and planes passing through each of the six, and through the axis, would mark on either surface six regular equidistant rays. The muscular fibres arise from both sides of each tendon; they diverge till they reach the greatest circumference of the coat, and having passed it, they again converge till they are attached respectively to the sides of the nearest tendons of the opposite surface. The anterior or posterior portion of the six viewed together, exhibits the appearance of three penniform-radiated muscles. The anterior tendons of all the coats are situated in the same planes, and the posterior ones in the continuations of these planes beyond the axis. Such an arrangement of fibres can be accounted for on no other supposition than that of muscularity. The mass is inclosed in a strong membranous capsule, to which it is loosely connected by minute vessels and nerves; and the connection is more observable near its greatest circumference. Between the mass and its capsule is found a considerable quantity of an aqueous fluid, the liquid of the crystalline.”

Fibrous Structure of the Lens.

Fig. 14.



Mr. Young's figure.

Fig. 15.



Leuwenhoeck's figure.

Supposing that these are muscular fibres, from their closeness and direction, they would stand acknowledged as forming the strongest and most powerful muscle of its size in the whole body; yet they act only on themselves, which requires the least possible degree of power. Again, how are they relaxed? What power is their antagonist? Mr. Young demonstrates not only the muscular fibres, but the tendons of the lens;* as if it were not evident that the lens acted merely on itself, which could require no concentrating of its fibres into tendons; for tendons are found in other parts of the body only where it is necessary to concentrate the whole power of the muscles so as to operate on one point.

We learn from Mr. Home,† that Mr. John Hunter had proved the lens to be laminated, and those laminae to be composed of fibres; and, upon the same authority, we learn that his opinion was in favour of the muscularity of its structure.—Mr. Home wished to follow out this subject, by including it in the Croonian Lecture. Mr. Home found, with the assistance of Mr. Ramsden, that a patient, after the extraction of the cataract, still retained the power of adapting the eye to the distances of objects. Indeed, we must be well aware that if a patient, after couching and extracting the lens, could only see at one given distance, an effect so very particular must have been long since observed. This was a conviction to Mr. Home and Mr. Ramsden, that the investigation was to be no further pursued in this tract, and they turned their attention, therefore, to the cornea.

Mr. Ramsden contrived an apparatus which, if the gentlemen engaged in the experiments have not deceived themselves, must put this question at rest. By Mr. Ramsden's ingenious contrivance, the head was fixed accurately, and at the same time a microscope was adapted to observe the changes in the convexity of the cornea as the eye was directed alternately to near and to distant objects. In these experiments, the motion of the cornea became distinct, its surface remained in a line with a wire which crossed the glass of the microscope when the eye was adjusted to the distant objects, but projected considerably beyond it when adapted to the near ones, and the space through which it moved was so great as readily to be measured by magnifying the divisions on the scale, and comparing them. In this way, it was estimated that it moved the 800th part of an inch (a space distinctly seen in a microscope magnifying 30 times,) in the change from the nearest point of distinct vision to the distance of 90 feet.

* See Philof. Trans.

† Ibid.

In the evidence from anatomical structure, I cannot think Mr. Home so happy. He was desirous of determining, more accurately than had hitherto been done, the precise insertion of the tendons of the four straight muscles, so as to know whether their action could be extended to the cornea or not: he found them to approach within one-eighth of the cornea before their tendons became attached to the sclerotic coat. But he did not stop here—he stripped off with them the anterior lamina of the cornea. Now, as it is supposed, in these experiments, that the action of the recti muscles upon the sides and back part of the ball compresses the humours, and makes them flow forward so as to distend the cornea; if the extremities of the tendons be inserted into the edge of the cornea and even pass over it, as Mr. Home has demonstrated, their effect would be to flatten the cornea, by drawing out and extending its margin. This is a circumstance which Dr. Monro has remarked; and Dr. Monro has also, with more accuracy of observation, found “all the tendinous fibres of the recti muscles firmly attached to the sclerotic coat at the distance of a quarter of an inch from the cornea, and no appearance that any part of them, or that any membrane produced by them, is continued over the cornea.”

Amongst the variety of opinions, the innumerable ingenious but contradictory experiments for discovering the manner in which the eye adapts itself to the distance of objects, I am, for my own part, much at a loss to determine which I should prefer. I have often doubted, whether these experiments were not in search of the explanation of an effect which has no existence. I have never been able to determine, why a very slight degree of convexity in the cornea of a short-sighted eye should be so permanent during a whole life-time, notwithstanding the perfect elasticity of the cornea, and its being so adapted as to alter its convexity by the action of the muscles.—Again, a near-sighted person, with the assistance of a concave glass, can command the objects to the distance of some miles, and with the glass still held to his eyes, can see minute objects within three inches of the eye. Now, I cannot conceive how the concave glass should give so great a range to the sight: as there can be no change in the glass, it must be the eye which adapts itself to the variety of distances; yet, without the glass, it cannot command the perfect vision of objects for a few feet. Again, a short-sighted person sees an object distinctly at three inches distant from his eye; at 12 feet, less distinctly: and when he looks upon the object at 12 feet, the objects beyond it are confused, just as in other men's eyes; but when he directs his attention to the more remote objects, those nearer become

indistinct. Now this indistinctness of the object, seen when he examines narrowly the objects beyond them, would argue, (did we admit this muscular power in the eye of adapting itself to objects,) that the cornea or the lens has become less convex, were we not previously convinced that the utmost powers of the eye could not bring the object at the distance of 12 feet, or any other intermediate distance, to be more distinctly seen than the fixed and permanent constitution of the eye admits.

I cannot help concluding, therefore, that the mechanism of the eye has not so great a power of adapting the eye to various distances as is generally imagined, and that much of the effect attributed to mechanical power is the consequence of attention merely. An object looked upon, if not attended to, conveys no sensation to the mind. If one eye is weaker than the other, the object of the stronger eye alone is attended to, and the other is entirely neglected: if we look through a glass with one eye, the vision with the other is not attended to. Now objects, as they recede from us, become fainter and fainter in their colours, and the general effect upon the eye is different from those which are near; and as it happens that the mind must associate with the sensation before it be perfect, there is, consequently, an obscurity thrown over distant objects when we contemplate near ones; as, on the other hand, the images of near ones are not attended to when the mind is occupied with distant ones, although they be nearly in the line with the distant object examined. I conceive it to be a good deal like that command of the attention which we can exercise upon very small bodies near us: of two small grains lying on the table, we can examine the one and neglect the other; though, if we attend to both, we can take them into the sphere of perfect vision; or, in other words, though they both have their images on the more sensible part of the retina. We can attend to one letter of a word, to the whole word, or to the page of a book. I cannot altogether deny the mechanical power of the eye in adapting it to the distance of objects, but I think this operation of attention has been too much overlooked.

CHAP. XII.

OF SEEING IN GENERAL.

THE eye is certainly the noblest of the organs of sense. It is that with which we should part the most unwillingly, and of which, when deprived, we are most helpless. A celebrated philosopher says, how much more noble is that faculty by which we can find our way in the pathless ocean, traverse the globe, determine its figure and dimensions, delineate every region of it; by which we can measure the planetary orbs, and make discoveries in the sphere of the fixed stars! Again, how admirable is that organ by which we can perceive the temper and dispositions, the passions and affections of our fellow creatures; and, when the tongue is taught most artfully to lie and dissemble, the hypocrisy is discovered in the countenance! we often are able to detect what is crooked in the mind as well as in the body! Yet, notwithstanding the perfection of the sense of seeing, much of this perfection is gained by the other senses, and particularly by that of touch. If the human body were motionless and inert, the sensation conveyed by the eye would be very imperfect; we should be able to conceive neither the distance nor the figure of objects. But, as it is the distance of the object, joined with its visible magnitude, is the sign of its real magnitude; and the distance of the several parts of an object, joined with its visible figure, becomes a sign of its real figure. Without this combination of the original sensation with the acquired perception, we should see form and colour without having any idea of its distance, or of the convexity of an object; we should have no measure of its length, or breadth, or distance.

Upon other occasions, we are apt enough to acknowledge the powers of association. But the connection of ideas is in no instance more constant and secret than in the ideas conveyed by sight and touch. When a solid body is presented to view, we see only the light and shade; but this raises in our mind the associated ideas from the sense of touch, viz. solidity, convexity, and angularity, "the visible idea exciting in us those tangible ideas," which, in the free and promiscuous exercise of our senses, usually accompany it. It is thus that

we attribute to the sense of sight what is the act of the memory and judgment.*

We have seen that the picture of an object is formed in the bottom of the eye. It was formerly sufficient to say, that the mind contemplates this image. We should say now, that this image is conveyed into the sensorium by the optic nerve. This is an hypothesis merely; and we have no more consciousness of the object being in the brain or sensorium than in any other part of the body: we may rather say, that the impression made on the organ, nerves, and brain, is followed by sensation, and that the intelligence is the joint operation of the whole.† Lastly, the metaphysician calls our sensations the signs of external objects; because the object itself is not presented to the mind, nor is there an actual resemblance betwixt the object and the sensation of it, but merely a connection established by nature, as certain features are natural signs of anger; or by art, as articulate sounds are the signs of our thoughts and purposes.

We are now naturally led to the consideration of some points, the full comprehension of which, requires the knowledge, both of anatomy and of the principles of optics.

PARALLEL MOTION OF THE EYES.

The axis of the eye is a line drawn through the middle of the pupil and of the crystalline lens, and which consequently falls upon the middle of the retina; and the axes of both eyes produced, are called the optic axes. But the axes of the eyes, it is evident, are not always parallel; for when both eyes are directed to a near object, the axes of the eyes meet in that object; but when we direct the eyes to the objects in the heavens, they may be considered as perfectly parallel in their axes, though perhaps not then mathematically so. To an observer, the eyes seem always moving in parallel directions; but nature has given us the power of varying them so, that we can direct them to the same point, whether remote or near. This, how-

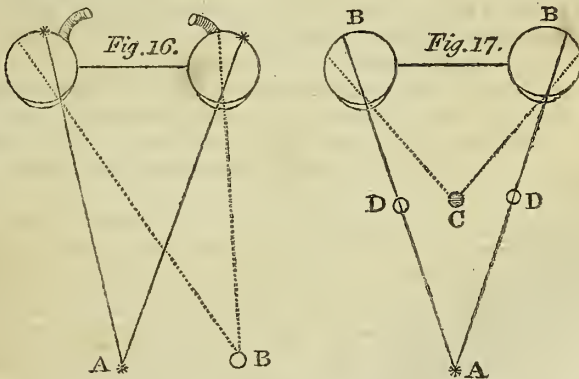
* See Dr. Jurin of Mr. Molyneux's problem, Smith's Append. p. 27.

† Euclid, and others of the ancients, contended that vision was occasioned by the emission of rays from the eye to the object. He thought it more natural to suppose, that an animate substance gave out an emanation, than that the inanimate body did. In 1560, the opinion was confirmed that the rays entered the eye.—The sensation was not always believed to be in the retina: It was by some believed that part of the sensation was to be attributed to the crystalline. Kepler, in 1600, shewed, geometrically how the rays were refracted through all the humours of the eye; so as to form a distinct picture on the retina; and also he shewed the effect of glasses on the eyes. See further, regarding the opinions of the ancients, Boerhaave Prelect. Acad. tom. iv. p. 282.

ever, is in some measure learnt by custom, and lost by disuse. A child has much difficulty in altering the distance of its eyes, which is the occasion of the vacancy of its stare: and again, we observe that a patient who has long lost one eye, is incapable of directing the axis of the blind eye without looking with the other, and even then, the blind organ does not follow the other with that perfect accuracy which exercise gives when both eyes are sound. By much practice and straining, the axis of the eyes may be much further altered from the natural parallelism, which wags and boys often do, so as to distort the eyes, and give a droll obliquity to the countenance.

Still, custom alters the direction of the axes of the eyes but a very little; for the natural constitution of the eye does not allow the child to turn his eyes in every different direction from each other. There is, on the contrary, as we have seen, a particular sensible spot in the retina, which makes it necessary to distinct vision, that this spot shall receive the concentrating rays of light; and the natural constitution of both eyes, is, that this spot in each eye shall have such a relation to that of the other, that the axes of both should be accurately in the middle of the eye-ball in order to produce single vision.

By voluntary squinting or depressing one of the eyes with the finger, objects appear double, because the optic axis is changed in the distorted or depressed eye, and the picture is no longer painted on corresponding points of both. This simple experiment leads us to consider what is the constitution and correspondence of the eyes, that, when each has the picture of the object impressed upon it, we should only see it single if the eyes are sound and perfect,



For example, the object A. in fig. 16., is exactly in the centre of the axes of both eyes; consequently, it is distinctly seen:

and it appears single, because the rays from it strike upon the points of the retina opposite to the pupils in both eyes. Those points have a correspondence; and the object, instead of appearing double, is only strengthened, in the liveliness of the image. Again, the object *B* will be seen fainter, but single, and correct in every respect. It will appear fainter, because there is only one spot in each eye which possesses the degree of sensibility necessary to perfect vision: and it will appear single, the rays proceeding from it having exactly the same relation to the centre of the retina in both eyes. Though they do not fall on the centre of the retina, they fall on the same side of the centre in both eyes. But if the eyes are made to fix steadfastly on an object, and if another object should be placed before the eyes within the angle which the axes of the two eyes make with the first object, it will be seen double, because the points of the retina struck by the rays proceeding from the nearer object do not correspond in their relation to the central point of the retina. Thus, the eyes *B B*, fig. 17., having their axes directed to *A*, will see the object *C* double somewhere near the outline *D D*. Because the line of the direction of the rays from that body *C*, do not strike the retina in the same relation to the axis *A B* in both eyes. Upon this principle, we may easily explain why objects, which are much nearer the eyes, or much more distant from them than that to which the two eyes are directed, appear double. Thus, if a candle is placed at the distance of ten feet, and I hold my finger at arm's length between my eyes and the candle, when I look at the candle, I see my finger double, and when I look at my finger, I see the candle double. This double vision occurs to us all frequently; but, unless we make the experiment purposely, we do not attend to it. Many other instances of the harmony, and of the want of it in the eyes, particularly the reverse of what these diagrams shew, may be easily produced, viz. the seeing two objects single: for, if we look at a half-penny and a shilling, placed each at the extremity of two tubes, one exactly in the axis of one eye, and the other in the axis of the other eye, we shall see but one piece of coin, and of a colour neither like the shilling nor like the half-penny, but intermediate, as if the one were spread over the other.

This relation and sympathy between the corresponding points of the two eyes, is, therefore, to be considered as a general fact, viz. that pictures of objects falling upon corresponding points of the two retinas, present the same appearance to the mind as if they had both fallen upon the same point of one retina; and pictures upon points of the two retinas which do not correspond, and which proceed from one

object, present to the mind the same apparent distance and position of two objects, as if one of those pictures were carried to the point corresponding with it in the other retina.

Several animals, we see, direct their eyes by very different laws from those which govern the motion of ours : but we are not to reason upon their sensations by the laws of vision of the human eyes ; we must take it as a principle, that nature has been bountiful to them also ; and that the result of organization in their eyes is perfect vision.

In birds, (if we except the owl,) the eyes diverge, and are directed to opposite sides. As the owl seeks his prey in the night, it may be necessary to the distinctness of his vision in weak light, that both eyes be directed to the object. Most fishes have their eyes directed laterally, though there are exceptions ; as those fishes which are flat, and swim at the bottom, have their eyes directed upward. In many insects, the surface of the eye has no resemblance to the cornea of viviparous animals ; but when examined with the microscope, it is seen to consist of a number of tubercles, each of which is as a distinct eye. In others, the eye is removed to the extremity of the moveable tenaculæ. Very large animals, as the whale, elephant, rhinoceros, hippopotamos, have, in proportion to their bodies, very small eyes : so have the animals which live much under ground ; and, in general, a large eye is a sign of the animal being able to see in obscure light, because there is proportionably a greater number of rays admitted into the eye. For the same reason, fishes have a peculiarly large eye and dilatable pupil, because the water is a more obscure medium, and, from the occasional roughness of its surface, much darkened and variable.

We must conclude, that in these varieties of the eyes, where there is a difference in number, position, and natural motion, there are different laws of vision adapted to these peculiarities and the exigencies of the animals. If we are to judge from analogy, we may suppose, that in many animals, there is no correspondence between points of the two retinas, or it is of a different kind from ours. In those which have immoveable eyes, the centre of the two retinas will not correspond so as to give the idea of one object, but of distinct objects, and in their respective places. In other animals, corresponding points would give false appearances ; and in such as turn their eyes in all directions, independently of each other, they would seem to possess a perception of the direction in which they move them, as we have of the motion of our arms.

SQUINTING.

We have seen, that there is a point in both retinas more acutely sensible to the impression of light and the image of objects, than any other part of all its concave surface. In a sound eye, this point is immediately opposite to the pupil.—There is a coincidence betwixt this point and the axis of the eye; and when we look to an object, its image strikes this point of the retina: but if it should happen that this sensible point of the retina should be changed, and not be exactly opposite to the pupil when the axis of the eye is in the line with the object, there will be an effort of the muscles moving the eye-ball to turn, so that the rays proceeding from the object shall strike upon the more sensible spot of the nerve.* Again, if the greater sensibility of the nerve should lie in its proper place, and a remote cause should occasion such an action of the muscles and distortion of the eye as we see in a squint, then the image will be double; for it no longer falls on corresponding points of the retina of each eye, and separate images are conveyed to the brain. If, however, this distortion continues, the single vision is gradually restored. Is there, then, in this case produced a new correspondence betwixt points of the retina which were before discordant? We find that this is not the case, by a very simple experiment.—In a person who squints, one of the eyes is directed to the object and the other appears to be turned from it: if the sound eye be shut, and the person be directed to look to an object with the other, it is directed to it with the proper and natural axis. Now this shows us that the sensibility of the proper spot in the bottom of the eye is not lost.—We must explain the single vision in eyes, one of which is distorted from its natural axis, upon another principle. Most people who squint, have a defect in one eye, and this is the distorted eye, while the other is directed in the true axis to the object. Now the mind does not attend easily to two impressions, the one being weaker than the other: in a short time the weaker impression is entirely neglected, and the stronger only is perceived.—So in squinting, the impression on the weak eye in a short time ceases to be attended to, the strong and vivid impression is alone perceived, and single vision is the consequence. It is evident, then, that those who squint must have a degree of imperfection in the strength of

* This was M. de la Hire's opinion.—He had an idea also that squinting was produced by the obliquity of the object. Both of these opinions are refuted by Dr. Jurin.

the image; for it is necessary to neglect the impression of one eye, to obtain distinct vision with the other; the consequence of this is frequently an attempt still further to distort the eye, and turn it so far inward or under the upper eye-lid that no distinct impression can be received upon it: at all events, they perceive the object only with one eye, although they may be said to see it with both; the perception being the combined operation of the organ and of the mind.

If the sensation of one eye be weak, it is very liable to be neglected altogether, and that eye is apt to wander from the true axis; and if the person be careless, or given to distort his eyes in childishness, a permanent squint may be given to the eyes.

Another cause of squinting, in children, is the being so laid in their cradle, that the light strikes obliquely into one of the eyes, whilst the other cannot see it; by which means one of the eyes only comes by degrees to be directed to the light while the sensation of the other is disregarded. What is very extraordinary in squinting, is the correspondence in the muscles of the eye, notwithstanding the great distortion of the eye-ball; for, when both eyes are open, as the sound eye turns in all variety of directions to the surrounding objects, the other eye still follows it, but preserves its distance, so as in a manner to avoid all interference. Blows on the head, drinking and smoking, and a variety of irritations, occasioning convulsions and distortion of the eyes, cause double vision. As this is evidently produced by the affection of the muscles moving the eye-ball,* since any change upon the retina could not give occasion to such distortions in a state of insensibility, we may naturally conclude, that squinting is sometimes the consequence of irregular action of the muscles; for if those transient causes are apt to affect them, so will they be apt to be permanently affected.†

* The command of the voluntary muscles is first lost in intoxication; and, therefore, it is more likely that the muscles should lose their natural action and correspondence than the retina.

† In Smith's Optics, there is a case of squinting and double vision occasioned by a blow. In Buffon's Dissertation, in the Acad. Roy. des Sc. 1743, squinting after long continued pain of the head. In the Mem. Roy. de l'Acad. des Sc. 1718, Hist. p. 29, there is a curious instance of false vision. I find also quoted several cases of strabismus from sudden fright, in *Ephem. Germ. cent 3 & 4. obs. 152. p. 349.* Ib. dec. 3. an. 8 & 11. ob. 57. p. 114. Ib. dec. 3. an. 9 & 10. obs. 67. "Novi Juvenem paralyti obnoxium, cui cum cæteris oculi sinistri musculis relaxatis, adducens fortius contraheretur propter oculum ita distortum objectum quodcumque duplex apparebat, nec quod verum esset distinguere potest." *Willis de anima Brut. P. Physiol. p. 77.* An instance of the loss of corresponding motions of the eyes, and strange illusions of sight. See in the Inquiry into the nature of mental derangement by Dr. Crichton, vol. i. p. 147.

We can distort our eyes by an unnatural effort, but we cannot squint: that is to say, we can bring our eyes into such a forced situation that we cannot see any thing distinctly; but we cannot keep one eye distinctly upon an object and turn the other from it.—Such a position of the eyes, at least (and which is exactly that of those who squint unintentionally,) I cannot, by any means, accomplish.* This shows the strict correspondence betwixt the moving muscles of the eye-balls. By this experiment, we shall find the difficulty of that method of correcting the squint proposed by Dr. Jurin, or of commanding motions of the eyes different from those which have been bestowed by nature, or acquired by habit. But habit I believe to be much more seldom the origin of squinting than is generally supposed. It is said, by Dr. Reid and others, that we see young people, in their frolics, learn to squint, making their eyes either converge or diverge when they will to a very considerable degree: why should it be more difficult for a squinting person to learn to look straight when he pleases? The reason of the greater difficulty is obvious, that in making the eyes converge or diverge, the will is acting upon both eyes equally; but to distort one eye inward or outward, and at the same time to keep the other fixed, is to me like an absolute impossibility. Most people, who squint, have a defect in the distorted eye, a weakness which they do not observe, from want of attention to the impressions upon that eye. It will be difficult to determine whether this defect be an original fault, or the effect of the want of use: since, by tying up the sound eye, the weak one becomes gradually stronger, so that the person becomes able to read with it, much may be attributed to the neglect of impressions.

It may be observed, that this neglect of the impressions, which are actually received, is not at all like that disuse, which is the consequence of no impression being received: for darkness increases the sensibility of the retina, while this dissipates and exhausts it. That squinting is not produced by the weakness of the impression received upon the nerve, would appear from the circumstance that opacity of the humours or the gutta serena do not occasion an alteration of the usual correspondence in the muscles moving the eye-balls.

It is said, that in those who have lost the sight of one eye, the habit of directing it to the object they look at is lost, because this habit is no longer of use to them.† This I have

* It is said that astronomers, who are much used to attend only to the impressions of one eye, are sometimes able to squint at pleasure. See Mr. Home Phil. Trans. 1797, p. 17.

† Dr. Reid.

never observed, nor should I think it apt to happen, unless the muscles of the eye had been injured from the same cause which destroyed the sight; at any rate, it is in a very imperfect degree, and not such as we should call a squint.

In regard to the cure of squinting, it seems the most reasonable, in the first place, to endeavour to strengthen the weak eye by use, and by tying up the sound one. In this case, the distorted eye becomes properly directed to the object, and the strength of the impression is in some degree restored. When this has been persevered in for some time, and the person is allowed to look at any object with both eyes, the weak eye will perhaps be again distorted from the true axis; but, probably, with a painful effort and double vision: which shows some progress in the recurrence of the two eyes, and their proper sympathy, and that the impression on the weak eye is at least attended to. After this, it will be time enough, by Dr. Jurin's method, to endeavour to correct the squint:—"place the child before you, and let him close the undistorted eye, and look at you with the other. When you find the axis of this eye fixed directly upon you, bid him endeavour to keep it in that situation, and open his other eye. You will now immediately see the distorted eye turn away from you towards his nose, and the axis of the other will be pointed at you. But with patience and repeated trials he will, by degrees, be able to keep his distorted eye fixed upon you, at least for some little time after the other is opened. And when you have brought him to continue the axes of both eyes fixed upon you, as you stand directly before him, it will be time to change his posture, and to set him first a little to one side of you and then to the other, and so to practise the same thing; and when, in all these situations, he can perfectly and readily turn the axes of both eyes towards you, the cure is effected. An adult person may practise all this with a glass, without any director, though not so easily as with one.—But the older he is the more patience is necessary. About twenty years ago, I attempted a cure, after this manner, upon a young gentleman about nine years of age, with promising hopes of success; but was interrupted by his falling ill of the small-pox, of which he died."

Dr. Jurin preferred this method to the use of tubes or shells with small holes in them, which have been recommended.—But what appears to me the great difficulty, lies in the strength of the impression received upon the sound eye, which, causing the impression of the weak eye to be entirely neglected, it is again thrown out of the line of direct vision. I conceive it, therefore, to be a necessary part of the experiment with tubes or shells, that the vision through the tube, applied to the sound

eye, shall be so obscured as to have some accordance with the lesser sensibility of the weak eye, and then, objects being seen equally with both eyes, a gradual accordance of the muscles may be produced. The conviction of the necessity of giving an equality to the strength of the sensation of both eyes must have struck M. de Buffon, since he says, in his Dissertation in the Academy of Sciences, that a plane glass should be applied to the weak eye and a convex one to the strong eye, so as to reduce the last to a state less capable of acting independently of the other.

But what is called a weakness, is very frequently, I am convinced, merely a short-sightedness in one eye: what the effect of this should be we may experience if we look to an object with both eyes, but with one of them through a concave or convex glass; if we are looking upon a book, there will be produced a confusion of the letters, but, by a little practice, the letters will become again distinct. By an attentive observation, we shall find that this is the consequence of attending solely to the impression received in the naked eye: nay, what is still more strange, we can attend, in this experiment, to the impression upon the point of the axis of one eye, and to the general impression of both. If, while looking upon the letters of a large page, I move the convex glass of a small degree of power sideways before my right eye, the whole letters of the page seem to move, leaving distinct and stationary a circular spot containing a word or two. Here, by no effort, while I look with both eyes, can I lose the steady and distinct sight of these few words, because their image is received upon the more sensible central point of the retina of my left eye: but all the other part of the sphere of vision I can see alternately, dimmed or distinct, as I choose to attend to the less powerful impression of the right eye, or the natural sensation of the left. We see, by this experiment, how easy it is to neglect the impression of one eye, if it be no stronger than that of the other, (and of course more easily if it be weaker,) and how impossible it is to neglect the more vivid impression.

From such a radical defect in the vision, as the humours of one eye having a different focus from the other, and consequently an indistinctness of vision produced from two images of different sizes intermingling their colours, children seem very frequently to be made to squint; and I have known adults, with a degree of the same inequality in the eyes, kept from squinting only by a particular attention to the direction of their eyes. M. de Buffon, in his Dissertation already quoted, after affirming what has been already delivered, viz. that no one squints with both eyes at once, says, he has observed three

instances in which the eyes, according to circumstances, were alternately distorted from the object. This he accounts for by finding that, with one eye, the letters of a book could be seen at the distance of two or three feet, and not nearer than fifteen inches; while, with the other, the letters could be distinguished at the distance of from four to fifteen inches only. Consequently, when looking to distant objects, the image being more distinct with the long-sighted eye, the other was turned from the object; but when objects at a small distance were seen, the image in the far-sighted eye being imperfect, it is turned from the axis, that it may not interfere with the stronger image of the other eye, which is now directed to the object.

A frequent effect of the weakness left by long fevers in children, is a squint which gradually goes off as the strength is restored. It is observed, also, that squinting and double vision are, in some fevers, a concomitant with delirium and phrenitis. This symptom proceeds, in all likelihood, from an unequal tension of the muscles of the eye-ball. The double vision is the effect of discordance in the action of the muscles.



CHAP. XIII.

OF THE EYE-LIDS, OF THEIR GLANDS, AND OF THE COURSE OF THE TEARS.

HAVING completed the description of the eye, as the organ of vision, we have now to attend to its connections, its adventitious membranes, the glands of the eye-lids, and the course of the tears. It is plainly necessary that the eye should not be loose in the socket; but that, in its rolling motion, it should still be attached; and that, although the delicate anterior surface must be exposed, the internal parts of the socket should be defended from the intrusion of extraneous bodies. This is accomplished by the tunica conjunctiva.

The *TUNICA CONJUNCTIVA*, or *ADNATA*, is the inflection of the common skin of the eye-lids. It goes a little way back into the orbit, and is again reflected, so as to come forward

and cover the fore part of the eye-ball. Here it is pellucid, and the white coat of the eye shines through it. It covers the cornea also; and here it is perfectly transparent; loses its character of vascularity, as the conjunctiva; and is assimilated to the nature of the cornea. As this coat is a continuation of the common integuments, it is, like them, vascular, and liable to inflammation. The tunica conjunctiva, is the common seat of ophthalmia. In the commencing inflammation, we see the vessels turgid or blood-shot: bye and bye, they elongate towards the surface of the cornea; the patient complains of dimness; the dimness becomes apparent to the surgeon; spots of opacity then form in the cornea; and the vessels of the conjunctiva now take a course over the turbid surface of the cornea. In this stage of the inflammation, by cutting the turgid vessels of the conjunctiva, we interrupt the source of blood for a time, and procure a small evacuation; but these vessels soon coalesce again, and the flow of blood is renewed.

The TUNICA ALBUGINEA is the thin tendinous coat formed by the insertion of the recti muscles, which expand over the anterior part of the eye. I would admit this into the enumeration of the coats of the eye, merely to prevent confusion of names, and to make intelligible the descriptions of some of the older writers. It is not properly a coat. Where the conjunctiva covers the anterior part of the eye, the white sclerotic coat is seen under it; and in consequence of this, the tunica conjunctiva is sometimes called albuginea.

A very material part of the structure of the eye still remains to be described; an apparatus by which the surface of the eye is preserved from injury, kept moist, and perfectly transparent.

The EYE-LIDS are composed of the common integuments, with this difference only, that they have a cartilaginous margin to give them shape, and muscular fibres, in the duplicature of their membrane, to give them motion. A small semilunar cartilage, which lies like a hoop in their edge, keeps them of a regular figure, and so as to close neatly over the eye. This cartilage having a triangular edge, and the base of the angle forming the flat surface of the margin of the eye-lid, they meet with the most perfect accuracy. Either end of this hoop-like cartilage is connected with the periosteum at the corners of the eye, so as to move with its fellow as upon a hinge. This cartilage of the eye-lid is called TARSUS.

The upper eye-lid only, is moved for the admission of light to the eye; it is raised by the levator palpebræ muscle. But the eye-lids are shut again by the orbicularis palpebrarum,

which acts on both eye-lids, and sometimes with such power, as to squeeze the eye-ball even to a painful degree.

The MEIBOMEAN GLANDS. These are very elegant little glands which lie under the inner membrane of the eye-lids.—About twenty or thirty ducts of these glands open upon the tarsus of each eye-lid. These ducts run up under the vascular membrane of the inside of the eye-lid, and minute glandular follicles, to the amount of about twenty, are, as it were, attached to each of these ducts. These glands exude a white sebaceous matter, which defends the edge of the eye-lid from the acrid tears, and closes them more accurately by its unctuousity. The vascularity of the inner surface of the eye-lid is subservient to these glands; for the vessels forming their ramifications round the little glands, secrete the sebaceous matter into them. This, then, is the seat of the ophthalmia tarsi; and following this inflammation, the edges of the eye-lids, and the mouths of the ducts, are sometimes eroded with little ulcers. These ducts are the seat of the stye. This is an inflammation and closing up of the mouth of one of the ducts, which then swells up into a little hard granule in the edge of the eye-lid, accompanied with inflammation of its cyst or surrounding membrane.

OF THE SECRETION AND COURSE OF THE TEARS.

THE LACHRYMAL GLAND is seated in the upper and outer part of the orbit, and behind the superciliary ridge of the frontal bone. It is of a flattened form, and is depressed into a hollow of the bone. Several ducts from this gland open upon the inner surface of the upper eye-lid. By the reflection of the membrana conjunctiva from the eye-lid over the surface of the eye-ball, dust and motes are prevented from getting behind the eye-ball: and when they have got under the eye-lids, the extreme sensibility of the tunica conjunctiva excites the lachrymal gland, and the orbicular muscle of the eye-lids, (which, by its pressure, accelerates the flow of the tears,) and the dust or motes are washed out. The puncta for re-absorbing the tears and conveying them into the nose, being at the inner angle or canthus of the eye-lids, we see the intention of the ducts of the lachrymal gland opening on the inside of the upper eye-lid towards the outer angle: for, by this means, the tears are spread over all the surface of the eye-ball, by the motion of the eye-lids, before they decline into the puncta. But the tears do not flow only when the gland is excited by motes; their secretion is perpetual, and, together with the motion of the eye-lids, they

perpetually moisten the surface of the eye-ball. Even during sleep they flow continually : and here we may admire a provision for their conveyance towards the inner canthus, in the inclination of the tarsus to each other ; for the eye-lids meet only on the outer edge of the broad surface formed by the tarsus, the consequence of which is, that a kind of gutter is formed in the angle by the inner edges of the tarsus not meeting, which leads the tears from the ducts of the lachrymal gland towards the puncta lachrymalia.

The PUNCTA LACHRYMALIA are the mouths of two ducts which form the beginning of a canal for drawing off the tears from the eye into the nose. These puncta are placed at the inner canthus of the eye, and on the termination of the tarsus of the upper and under eye-lid : they are surrounded by a rigid substance ; and their patent mouths absorb by capillary attraction. They lead the tears into the lachrymal sac, and thence the tears pass into the nose.

The CARUNCULA LACHRYMALIS is that little granulating-like body which lies in the inner angle formed by the two eye-lids. Very small hairs are seen to sprout from it, and some small sebaceous follicles open upon its surface. Connected with the caruncula lachrymalis is the MEMBRANA OR VALVULA SEMILUNARIS. This is a vascular membrane which is drawn from under the caruncula lachrymalis by the direction of the eye outward, so as then to appear like a web spread over the white of the eye near the inner canthus. By directing the eye towards the nose, this membrane is again accumulated about the caruncula. This, then, is a very particular mechanism, not as is generally described, for applying the tears to the puncta lachrymalia, but for accumulating and throwing out the motes and dust from the eye, and for guarding the puncta from the absorption of such little particles as might irritate or obstruct them.

In birds, the valvula semilunaris is drawn, by a muscle and small tendon inserted into it, quite across the eye, so as to act like a third eye-lid ; it is in them called membrana nictitans.

The LACHRYMAL SAC AND DUCT lie in the os unguis or lachrymale. The sacculus is a bag of an oblong or oval figure ; it is sunk into the fossa of the os unguis, and defended by the frontal process of the superior maxillary bone ; and it is covered by the ligamentous connection of the orbicularis muscle.— This sac is the dilated upper end of the nasal duct ; and into it the two canaliculi lachrymales (the extremities of which are the puncta,) open as distinct tubes.*

* Dr. Monro.

Two coats are described as covering the lachrymal sac ; a nervous, white, external coat ; and a vascular, pulpy, pituitary membrane. This sac diminishing towards the lower part, and being received into the complete canal of the bone, becomes the nasal duct. Taking a course downward and backward, it opens into the nose under the inferior spongy bone.—The lachrymal sac and duct are by some conceived to be muscular, so as to enable them to convey the tears into the nose ; or it may be conceived, that they act like a syphon, the duct reaching down into the nose acting like the long leg of the syphon, and drawing the tears in at the openings of the puncta. But I think it would appear, that the connection of the orbicularis muscle over the sac is of a nature to accelerate the passage of the tears, and even perfectly to compress the sac. The lachrymal sac and duct are very frequently diseased and obstructed. For example, after small-pox, syphilis, or in scrophulous constitutions, the inner membrane of the sac being of the nature of the pituitary membrane of the nose, inflames, swells, and adheres. The consequences of this are, first, a swelling of the lachrymal sac in the inner angle of the eye, and a watery or weeping eye ; upon pressing the tumour, the tears, mixed with mucus, are forced back through the puncta ; by and by the sac inflames and suppurates ; matter is discharged by pressure of the sac : and, lastly, it is eroded and bursts out, discharging the tears and matter on the cheek. This is the complete character of the fistula lachrymalis. While the sac bursts outwardly, it often does further mischief within, by making carious the thin lamina of bone in which it lies. The theory of the ancients, with regard to this disease, was that the disease was proceeding from the caries of the os unguis, and they perforated with the actual cautery, until the patient smelt it in the nose ! as much with the intention of remedying the caries, as to give passage to the tears. But it is not the bone which is the obstruction to the perfect cure of this disease by operation, but the membranes, which close again after the most ingenious attempts to preserve the passage. The *vis medica*trix, in this instance, seems not to be so well aware of her interest as some physiologists would inculcate. She is, here, ever at variance with the artifice of the surgeon.

BOOK II.

OF THE EAR.



CHAP. I.

OF SOUND, AND OF THE EAR IN GENERAL.

THE ear is that organ by which we are made susceptible of the impression of sound.

Sound is the motion of elastic fluids, occasioned, in general, by the vibration of solid bodies : and this vibration of the solids depends upon their elasticity or tension : or sound may be produced by the vibration and motion of the air primarily, but not without the intervention of solids. The human voice, for example, does not depend merely on the percussion of the air, but on that vibration, as combined with the tension and consequent vibration of the glottis, excited by the current of air ; which, again, is modified by the mouth. In the same manner, the sound and variety of tone, in musical instruments, depend on the joint effect of the vibrations of the solids, and of the air.

There is no body impervious to sound, or, in other words, incapable of transmitting the vibration. That sound is communicated through the medium of the air, we know from the circumstance, that a bell, when struck in a vacuum, gives out no sound : and again, from this, that the condensed state of the atmosphere affords an easier communication of sound, and conveys it to a greater distance. The velocity of the impression transmitted by the common air, is computed at 1130 feet in a second ; and sound, when obstructed in its direct motion,

is reflected with a velocity equal to that with which it strikes the solid body by which its progress is interrupted.

That water conveys the vibrations producing sound, has been proved by experiment. It was once the saying of naturalists, that, to suppose fishes to have the organ of hearing, would be to conceive that an organ were bestowed upon them without a possibility of its being of use. But we are assured of the fact, that, on the tinkling of a bell, fishes come to be fed;* and it was the custom for the fishermen on the coast of Britany, to force the fish into their nets by the beating of drums,† as our islanders are at present accustomed to do when the larger fish get entangled amongst the rocks. We are told, that, in China, they use a gong for the same purpose. These facts were once of importance, though more accurate observation has now made them superfluous. The Abbe Nollet took much pains to decide the question, whether water was a medium for sound. After considerable preparation, and acquiring a dexterous management of himself in the water, (for which he takes great merit to himself,) he found that he could hear under water the sound of the human voice, and even distinguish conversation and music. The human ear being an organ imperfectly adapted to this medium of sound, these experiments do not inform us of the relative powers of air and water in the transmission of sound. But another experiment of the Abbe Nollet proves, what indeed to me is sufficiently evident, from the structure of the ear of fishes, viz. that the water transmits a much stronger vibration than the air. When he sunk under water and struck together two stones which he held in his hands, it gave a shock to his ear which was insupportable, and which was felt on all the surface of his body, like that sensation which is produced when a solid body held in the teeth is struck by another solid body.‡ He observed in other experiments, that the more sonorous the bodies struck were, the less vivid was the impression; by which it would appear, that water, though it conveys an impression more strongly to the ear than the air, is not equally adapted to the resonance and variety of

* Boyle.

† M. l'Abbe Nollet, Acad. R. des Sciences. Naturalists were very incredulous of the effect said to be produced by music on lobsters. Some may be so still; but we may trust the following observation of Minassius, in his Dissertation. "*Su de timpanetti dell udito scoperti nel Granchio Paguro.*" "Proprii observationibus certior factus asserit obscura nocte, placidoque mari, quoties piscatores ardentibus facculis paguri in littore hærentis oculos lucis fulgore perstringunt, ut stupido, et pene præstigiato animale potiantur, si forte rumor aliquis ingruit. CANCRUM illico se e littore subducere recipereque intra undas." See *Scarpa Disquisitiones Anatomicae de Auditu in Insectis, &c.*

‡ These experiments were repeated by Dr. Monro. See his Book of Fishes.

tonc. Indeed, this is a natural consequence of the water, a fluid of greater density being in close contact with the sounding body, and suppressing its vibration. In these facts, we shall find the explanation of some peculiarities in the structure of the ears of fishes.

Thus, we see, that the vibration of a solid body is continued through the air and through water, until reaching the organ of hearing, it produces the sensation of sound. Sound, it will be evident, is also communicated through solids. When we put the ear to one end of a log of wood of thirty feet in length, and strike upon the other, we are sensible of the impression; and when a solid body applied to the bones of the head, or to the teeth, is struck, we are sensible of the noise;* and this is felt even by those who are deaf to impressions conveyed through the air: indeed it is partly in this way that we are to judge whether deafness may be cured by operation, as depending upon some injury of the mechanism of the organ, or whether it be an incurable affection of the nerve or brain itself. If the sound be perceptible when conveyed through the teeth, or when a watch, for example, is pressed upon the bone behind the outer ear, we are assured that the internal organ is unaffected; and upon enquiring farther into the case, we may find that the deafness proceeds from some disease of the outer tube of the ear, or of that tube which leads into the throat, and that it can be remedied.

CHAP. II.

GENERAL VIEW OF THE VARIETIES IN THE EARS OF ANIMALS.†

THERE is in the scale of animals a regular gradation in the perfection of the organ of hearing. But, in the human ear, we find united all the variety of apparatus for communicating

* Perhaps we cannot call this sound.

† In the following short account of the comparative anatomy of the ear, although I have taken every assistance in my power from books, I have described the structure, in all the examples, from my own dissections and observation.

the vibration to the internal organ, and along with this the most extensive distribution of nerves in the labyrinth, or in most division of the ear, to receive that impression.

The ultimate cause of this more complex structure is the greater power with which man is endowed of receiving, through the ear, various impressions of simple sounds : language, music, and various modifications of the sense, of which the lower animals are incapable.

As, in treating of the anatomy of the eye, we do not attempt to investigate the manner in which light acts upon the retina, in producing the sensation of colours, but endeavour merely to explain the structure of the eye ; to show how the coats support and nourish the humours ; how the humours are subservient to the concentration of the rays of light, and assist their impulse upon the retina : so, in the same manner, in explaining the structure of the ear, we need not investigate the philosophy of sound, nor the nature of those impressions which are made by it on the sensorium through the nerves ; our views are limited to the structure of the ear—we have to observe the mechanism by which the strength of vibrations is increased and conveyed inward to the seat of the sense, and the manner in which the nerve is expanded to receive so delicate an impression.

The method of studying this subject, which is at once the most instructive and the most amusing, is to trace the various gradations, in the perfection of the organ, through the several classes of animals. It is chiefly by comparing the structure of the viscera, and the organs of sense in animals and in man, that comparative anatomy is useful in elucidating the animal œconomy. For example, in the stigmata and air-vessels of insects and worms ; in the gills of fishes ; in the simple cellular structure of the lungs of amphibæ ; in the more complicated structure of the lungs of birds ; we observe one essential requisite through the whole gradation, viz. the exposure of the circulating fluids to the action of the air. And in this variety of conformation, we see the same effect so modified as to correspond with the habits and necessities of the several classes of animals. In the same manner, with regard to the circulating system, we are taught the explanation of the double heart in the human body, by tracing the variety of structure through the several classes of animals ; from the simple tube circulating the fluids of insects, the single ventricle of fishes and reptiles, the double auricle and perforated ventricle of amphibæ, up to the perfect heart of the warm-blooded animal. The organs of generation, and the œconomy of the fœtus in utero, is, in the same degree, capable of illustration from comparative anat-

my. But most especially, in the structure of the ear, is there much scope for this kind of investigation. We find such varieties in the ear of reptiles, fishes, birds, and quadrupeds, as lead us, by gradual steps, from the simpler to the more complex structure.

The simplest form of the organ of hearing is that in which we find a little sac of fluid, and on the inside of the sac the pulp of a nerve expanded. If an animal, having such an organ, breathe the air, a membrane closes this sacculus on the fore part; and, by means of this membrane, the vibrations of the air are communicated to the expansion of the nerve through the fluid of the sac. But if the animal inhabits the water only, it has no such membrane to receive the impression; the organ is incased in bone or cartilage, and instead of the membrane, some small bone or hard concreted matter is found in contact with the pulp of the nerve. The sound, passing through the waters, is, in such case, conveyed to the organ not by any particular opening, but through the bones of the head; and this concrete substance, partaking of the tremulous motion, communicates the sensation to the nerve.*

For example, in the CRAB and LOBSTER, we find a prominent bony papilla or shell, which is perforated with a membrane extended across the perforation, and behind this membrane there is a fluid, in which the nerve is expanded, and which receives the impulse conveyed to the membrane. In the CUTTLE-FISH, again, there is no external opening; there is merely a little sac under the thick integuments: this sac has in it a small concretion or bone for receiving the vibration; which, in this animal, is conveyed by a more general impression upon the head than in those last mentioned; and the vibration of this loosely poised bone or concrete seems equal to the provision of the membrane which, in the crab, closes up the external opening in the perforated shell.

In FISHES, there is a considerable variety of structure. Those which remain perpetually under water, have not the outer membrane, nor any apparatus for strengthening the first-received undulations of sound. But such as lie basking on the surface of the water, and breathe through lungs, have an external opening—a canal leading to the membrane, and behind the membrane bones to convey the vibration to the internal parts, and these internal parts, the seat of the sense, are actually as perfect as in terrestrial animals.

* It is conceived by some that the antennæ of insects conveys to them the vibration of bodies, and that they may be considered as an imperfect variety of this organ.

In neither of the species of fishes, the cartilaginous nor spinous fishes, is there a proper external opening, as in animals breathing air. They receive the impulse from the water, upon the integuments and bones of the head; but within the head, and in the seat of the sense, they have a most beautiful apparatus for receiving and conveying those general vibrations to the expanded nerve. There is in every ear, adapted to hearing under water, a bone or concretion, placed so as to vacillate easily, and which is destined to agitate the fluid in which it is suspended with a stronger vibration than could be produced merely by a general impulse. Besides this provision in fishes, there is a very elegant structure for still further increasing the surface destined to receive the impulse, and for exposing to that impulse or vibration a larger proportion of the expanded nerve. It consists of three semicircular tubes, which penetrate widely within the bones of the head. They are filled with a fluid, and have in their extremities a division of the nerve which is moved or otherwise affected by the vibration of the fluids contained within the tubes.

There is a slight variety, however, in the ear of cartilaginous fishes. In the head of the *SKATE*, for example, there is under the skin, at the back of the head, a membrane extended across a pretty regular opening. This, however, is not considered as the opening of the ear; but a passage, like a mucous duct, which is beside it, has given occasion to a controversy between Professors Scarpa and Monro; and it may not be out of place to inquire a little into this disputed point.

We have seen that water conveys the sound of vibrating bodies with a shock almost intolerable to the ear, and with a particular and distinct sensation over the whole body. We see, also, that, in the greater number of fishes, there is confessedly no external opening, the whole organ is placed under the squamous bones of the head. Yet the cartilaginous fishes, which are supposed to have an external ear, swim in the same element, and are in no essential point peculiar in their habits. And we should receive with caution the account of any peculiarity in the organ of hearing of one class of fishes, which is not common to all inhabiting the same fluid. Such animals as occasionally pass from the water into the air, must have a membrane capable of vibrating in the air; but, even in them, it is expanded under the common integuments, and protected by them. Were it otherwise, when the creature plunged into the water, it would be assailed with that noise, (confounding all regular sounds,) of which man is sensible when he plunges under water. It appears opposite to the general law of nature, to suppose any species of fish having that simple and more de-

licate membrane, which is evidently intended to convey atmospheric sounds only, while, on the other hand, creatures living in the water alone, should have an organization fit to endure the stronger vibrations of their denser fluid, and which would be useless and absurd in those existing in our atmosphere.

When we come to examine the ear of the skate, we find, that what Dr. Monro conceives to be the OUTWARD ear of the fish,* is really, as represented by Dr. Scarpa, a mucous duct merely; † which does not lead into the sacculi of the vestibule and semicircular canals, as appeared to Dr. Monro; and that to suppose this would be to acknowledge the free access of air and water to the immediate seat of the organ, and to the soft pulp of the auditory nerve, a thing absurd in every view, impossible in nature, and very wide of the truth. ‡ To me, it appears, that this narrow duct cannot be considered as the external ear; because we find in the skate a proper membrane under the thin integuments, quite unconnected with the duct, for transmitting the sound; and, upon following this mucous duct, we find it taking a circuitous course, and filled with a strong gelatinous matter; it is every where narrow, and filled with a glutinous secretion. It has no membrane stretched across it, and bears no resemblance to the external ear of any other animal.

We may conclude, then, that fishes have no external opening like terrestrial animals; that, instead of this outward provision they have the moveable bone within the organ. Although the cartilaginous fishes have a membrane extended over part of the organ, which, in the spinous fishes, is completely surrounded with bone, it is not to be considered as capable of the tremulous motions of the membrana tympani of terrestrial animals, but may be considered as analogous to the membrana fenestræ ovalis: and, since it lies deep under the integuments, we have no reason to believe that sound is transmitted to the organ of

* "In the upper and back part of the head of a skate, and in a large fish weighing 150 pounds, at the distance nearly of one inch from the articulation of the head, with the first vertebra of the neck or atlas, two orifices, capable of admitting small sized stocking wires at the distance of about an inch and a quarter from each other, surrounded with a firm membranous ring, may be observed. These are the beginnings of the Meatus Auditorii Externi." Treatise on the Ear, p. 208.

† Dr. Scarpa, speaking of this opinion of Dr. Monro, says, "qua in re vehementer sibi hallucinatus est, ostia nimirum ductuum mucosorum, ut manifestum est, pro auris meatibus accipiens. Etenim omnino nullum est in cartilagineis piscibus ostium auditus extus adaptum, membranaque fenestra ovalis sub communi integumento recondita jacet et cooperta."

‡ "Quod et absurdum est et a rei veritate quam maxime alienum." Vid. *Anatomica Disquisitiones de auditu et olfactu, auctore. A. Scarpa.*

hearing in fishes, any otherways than through the general vibration of the head.

The organ of hearing in amphibious animals, demonstrates to us a difference in the manner in which the sensation is received ; for they have both the outer membrane to receive the vibration of the air, and a mechanism of small bones to convey this motion into the seat of the sense ; and they have, besides, within the ear itself, a chalky concretion : a provision plainly intended for propagating the motion communicated through the water.

In serpents, birds, and quadrupeds, we shall hereafter trace the various gradations in the perfection of this organ. We shall find, that, as the animal rises in the scale, the cavities and tubes of the ear are extended and varied in their form. Now, I conceive that, while the multiplied forms of the tubes and sphericles of the internal ear afford a more expanded and susceptible surface for receiving impressions, the consonant forms of the parts enable them to receive a stronger vibration, and a more perfect and modified sound.

A cord of a musical instrument will vibrate when another in exact unison with it is struck. The vibration communicated to the air is such, as is adapted to the tension of the sympathetic cord ; and no other percussion of the air, however violent, will cause it to sound. Again, the air passing through a tube of certain dimensions, will not communicate to it a motion, nor call forth its sound, while the air, passing in equal quantity through a tube of one degree of difference, will rise into a full note. What holds true in regard to the unison of cords, is also true of cylinders, or even of the walls of a passage or room, a certain note will cause the resonance of the passage or room, as a certain vibration will call forth the sound of the tube of an organ ; because it is in all these instances necessary that the impulse be adapted to the position of the surfaces and their powers of reverberation. Sound, as allied to music, consists in the succession, the rhythm or time of its return upon the ear.

These few facts illustrate what I mean, by saying, that the various forms of the internal ear of animals, as they advance in the scale, give additional powers to their organ. In the first example of the simple ear, where a bone vibrates on the expanded nerve, I should conceive that the sensation were, in consequence of this simple percussion, capable of little variety ; but in animals where, besides this simpler mechanism, there are semicircular canals, and more especially in those animals, which have still a further complication of the forms of the ear, certain sounds will be peculiarly felt in each of these several cavities and convolutions ; and, while the sensation is becom-

ing more distinct, by the perfection of the organ, it admits, also, of a greater variety of sounds or notes : so that a certain state of vibration will affect the semicircular canals, (one or all of them,) and produce the sensation of sound, which would not at all affect the vibration of the simple lapilli lying in their sac.



CHAP. III.

DESCRIPTION OF THE ORGAN OF HEARING IN PARTICULAR ANIMALS.



IN THE LOBSTER AND CRAB.

IN these animals, the structure of the ear is very simple ; but it appears to me, that Professor Scarpa, in his description, has imagined the organ to be more simple than it is in nature.

In the **LOBSTER**, there projects from near the root of the great antenna, an osseous papilla of a peculiarly hard and friable nature. In the point of this papilla we observe a foramen, and a membrane stretched over it. This is the seat of the organ of hearing. It is described as containing a sac of a pellucid fluid, which adheres to the membrane, while the auditory nerve is expanded upon the lower surface of the sac. Now, the lobster, being an animal which can live on land as well as in water, Scarpa gives this as an instance of a structure calculated to receive the sensation of sound equally well from the water or from the atmosphere. But, from the figure I have given of the ear of this creature, it will not appear to be so exceedingly simple ; while there is evidently a provision for the reception of the vibration communicated through the water, though it does not indeed strictly resemble that which is commonly found in the ears of fishes. There is suspended behind

the sacculus, and in contact with the nerve, a small triangular bone, which, when pulled away,* is found to hinge upon a delicate cartilage. This bone seems evidently intended, by its being thus suspended in the neighbourhood of the PULP OF THE auditory nerve, for impressing upon that nerve the vibration from the water. The lobster, then, has, like the amphibious animals, a double provision for receiving the communication of sound alternately from the water or from the air.†

The ear of the CRAB differs from that of the lobster in this, that under the projection, there is a moveable case of bone, to which we see a small antenna attached. Within this is the organ of hearing; and there is here an internal provision for the transmission of sound to the auditory nerve, which consists simply in a few circumgyrations of a pellucid and flexible cartilage: an inspissated fluid surrounds this gyrous cartilage, while the pale auditory nerve is expanded behind it.

OF THE EAR OF FISHES. In the heads of fishes, there is a cavity separated by a thin vascular membrane from that which contains the brain. Within this cavity there is a sacculus distended with a fluid, and containing a small bone;‡ on the inside of this bag, (which is called the sacculus lapillorum,) a great proportion of the auditory nerve is expanded. In the cartilaginous fishes, there are three lapilli§ contained in their proper capsules, and surrounded with a gelatinous matter,|| each of the lapilli having its appropriated division of the acoustic or auditory nerve distributed upon it in a beautiful net-work.

This cavity in the head of fishes, resembles the centre of the labyrinth in the human ear, and is called the vestibule. Within the vestibule there is a limpid fluid, intersected every where by a delicate and transparent cellular membrane; and the parts within the vestibule are supported in their place by this tissue, which is similar to that which supports the brain in fishes.

Besides this central part of the organ in fishes, there are departing from the vestibule three semicircular cartilaginous canals,¶ within which, are extended membranous canals.—These membranous tubes contain a fluid distinct from that

* See fig. 2.

† From the mucous-like transparency of the nerve in the lobster, it is difficult to ascertain its exact relation to this bone.

‡ See plate, fig. 3.

§ In many of the spinous or squamous fishes, there is only one. In cartilaginous fishes, these bodies are not like bone, but like soft chalk. In the spinous fishes, on the other hand, they are of the shape of the head of a spear, and hard like stone.

|| The gelatinous matter is rather before the bones, and distending the little sacculi.

¶ See plate 7. fig. 3. and fig. 4. D D D.

contained in the common cavity of the vestibule, nor have they any communication with the sacculi, which contain the lapilli, although they are connected with them.* These cartilaginous canals are of a cylindrical form, and, being as transparent as the fluid with which they are surrounded, are not readily distinguished in dissection. Each of the cartilaginous canals is dilated at one of its extremities into a little belly, which is called the ampulla.

The auditory nerve in cartilaginous fishes† is first divided into two fasciculi, which are again subdivided into lesser nerves. These go to the three sacculi lapillorum, and to the ampullulæ of the semicircular canals. Before the division of the nerve peculiar to the sacculus pierces it, and is finally distributed, it forms a singular and intricate net-work of filaments. The branches to the ampullulæ are raised on a partition which is opposed to the mouth of the cylindrical part of the tube.

In the spinous fishes, the three semicircular canals unite in a common belly; but in cartilaginous fishes, the posterior semicircular canal is distinct from the others.

In fishes, all the parts of the ear are filled with a matter of a gelatinous consistence, or viscid fluidity; and the whole sacculi and semicircular canals are surrounded with fluid. That jelly is the most susceptible of vibration, is evident, when we fill a glass, and allow a body to fall into it; for then the delicate vibration is communicated to the finger on the outside of the glass, or, by striking the glass, we may observe the tremulous motion of the jelly. The semicircular canals, it is evident, are well adapted to receive the extensive vibrations communicated through the bones of the head, and to convey them inward to the nerve expanded in the ampulla.

From the simpler to the more perfect aquatic animals, we may trace several links of the chain by which nature advances towards the perfect structure of the ear. We return now to observe, in the first example of terrestrial animals, the most simple state of that part of the organ which receives the sensation; but where the structure of the receiving organ is the most simple, the mechanism for receiving the vibration and conveying it to the internal ear, is modified and adapted to the atmosphere.

OF THE EAR IN REPTILES AND AMPHIBIOUS ANIMALS.

IN REPTILES, which form the intermediate class of animals

* So Professor Scarpa asserts, in contradiction to others.

† The fifth pair of nerves in fish answers to the seventh in man; it has the same division into the *portio mollis* and *dura*.

betwixt fishes and quadrupeds, the ear has also an intermediate structure; in some individuals of this class the ear resembles that of fishes, such as we have described, while, in others, it resembles more nearly the common structure of terrestrial animals.

In the *salamandra aquatica*, a variety of the lizard, there is a foramen ovale,* deep under the integuments. In this foramen there is a cartilage, in immediate contact with which, there is a common sacculus lying in the cavity or vestibule; and in this little sac there is found a cretaceous matter: there are here, also, semicircular canals, with ampullulæ and a common belly connecting them. In this animal, then, it is evident, the ear is similar in structure to that of the cartilaginous fishes.†

In the *FROG*, the outward apparatus is different, but the internal ear is simple.‡ Under the skin of the side of the head, a little behind the prominent eye, we find a large circular opening, which tends inward in a funnel-like form: and from the upper part of the circle of this meatus we find a small elastic bone, or cartilage suspended. This bone is in contact with the common integuments of the head, which are stretched over the little cavity. This first bone is placed at a right angle with a second bone, and both are lodged in a proper tympanum.§ This second bone swells out towards its inner extremity, and is accurately applied to the foramen ovale. The foramen ovale opens into a cavity which we must call the vestibule, and which, in this creature, is peculiarly large in proportion to its size. This vestibule contains a sac, upon which the nerve is expanded: it contains also a chalky soft concretion, which is of a beautiful whiteness, and of a regular figure when first seen, but has no solidity.|| The vestibule here, as in all other animals, being the immediate seat of the sense, is filled with fluid.

In *SERPENTS*, the mechanism external to the seat of the organ is less complete than in the frog. From the scales behind the articulation of the bone which keeps the lower jaw

* This is the appropriated appellation of the opening which leads from the outer cavity of the ear, or tympanum, into the seat of the proper organ where the nerve is expanded.

† It is said by naturalists, that the salamander never has been heard to utter a cry; and as dumbness is in general coupled with deafness, it is natural to suppose it has no ears. This is to consider the organ as subservient to conversation!

‡ See plate, fig. 5 and 6.

§ This tympanum, being a cavity containing air, has communication with the mouth by a tube, which we shall afterwards find called eustachian tube. Several have erroneously described this animal as receiving sounds through the mouth.

|| See fig. 6. v.

extended, a little column of bone* stretches inward and forward. This bone has its inner extremity enlarged to an oval figure, and is inserted into the foramen ovale. This creature has no membrana tympani, nor does it appear to have so good a substitute as the frog: the outer extremity of the bone seems rather attached to the lower jaw by a cartilaginous appendage and small ligament.† Within the scull, serpents have the little sac, with the cretaceous matter and semicircular canals, united by a common belly.‡

In the **TURTLE**, we find a proper tympanum, and by lifting the scaly integuments from the side of the head a little above the articulation of the lower jaw, we open this cavity.— Through this cavity there extends a very long and slender bone, which, upon the outer extremity, is attached by a little elastic brush of fibres to the cartilaginous plate under the integuments, while the inner extremity is enlarged, so as to apply accurately to the foramen, which opens into the vestibule; and a passage also opens from the cavity of the tympanum into the fauces. In this animal, as in all which we have classed under the present division, the internal ear consists of a central cavity, or vestibule, which contains a sac with fluid, and cretaceous matter, and of three semicircular canals connected by a common belly. This common belly of the semicircular canals has no communication with the sacculus vestibuli which contains the cretaceous matter, further than as it lies in contact with it, and as they both lie surrounded by a fluid; they equally receive the impression of the little bony column, the extremity of which vibrates in the foramen ovale.

There being enumerated forty or more varieties of the **LACERTA** or **LIZARD**, many of these have very different habits. Some of them never pass into the water, but inhabit dry and dusty places. The *lacerta agilis*, or common green lizard, which is a native both of Europe and of India, is nimble, and bask, during the hot weather, on the trunks of old trees and on dry banks; but on hearing a noise, it retreats quickly to its hole. It has the skin over the tympanum extremely thin, and such as to answer precisely the office of the membrane of the tympanum. So all the varieties of reptiles which, in their habits and delicacy of hearing, resemble terrestrial animals, have either the membrane of the tympanum or a skin so delicate as to produce the same effect; while those, which inhabit

* Plate, fig. 7. B.

† See Scarpa, tab. v. fig. ix.

‡ Serpents are affected by music; and they will raise and twist themselves with every variety of lively motion to the pipe and tabor.

the water, have a rough integument, or a hard scale, drawn over the tympanum. Besides this, some have a small muscle attached to the bone, which runs across the tympanum; it is like the tensor tympani, and is another step towards the proper structure of the terrestrial ear.

OF THE EAR IN BIRDS.

Comparing the internal ear of birds with that of those animals which we have already described, we find a very important addition. We find here the internal ear (or labyrinth, as we may now call it,) consisting of three divisions: the vestibule, or middle cavity; the semicircular canals; and the cochlea; which last is an additional part, and one which we have not in the class of animals already described. Leading into these three cavities, there are two foramina: the *FENESTRA ROTUNDA*, and the *FENESTRA OVALIS*; and both these openings have a membrane stretched over them in the fresh state of the parts. The first, the fenestra ovalis, or foramen ovale, receives the ossiculus auditus, which is in birds like that which we have already described in reptiles.* This ossiculus connects the membrana tympani (which is here of a regular form) with the vestibule, and conveys the vibration of the atmosphere to it.

The semicircular canals are here also three in number, and are distinguished by the terms minor, major, and maximus; but as the major and minor coalesce at one of their extremities, and enter the vestibule together, the semicircular canals open into the vestibule by only five foramina in place of six. Each of the semicircular canals is dilated at one extremity into an elliptical form, while the other extremity is of the natural size of the diameter of the tube. These canals are formed of the hard shell of bone, and are surrounded with bone, having wider and more open cancelli.

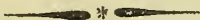
In the dry state of the parts, we find a cord passing through the semicircular canals, which some have called the *ZONULÆ NERVÆ*. But these are the membranous canals, which are

* Mr. Home, in his lecture on the muscularity of the membrana tympani, (vid. Phil. Transf. A. 1800,) says, in birds this membrane has no tensor muscle to vary its adjustments, but is always kept tense by the pressure of the end of the slender bone. This is a very imperfect account of the mechanism of the tympanum in birds. There are two bones, or one small bone with a cartilage, which lies along the membrana tympani. This elastic cartilage has two little tendons attached to it. Even the slender bone which stretches from the cartilage to the foramen ovale, the inner extremity of which is enlarged to fill up that hole, seems to have a small tendon inserted into it; but whether this be a muscular or ligamentous connection, I am unable at present to say.

contained within the bony ones, dried and shrunk up. Within the bony cavities of the labyrinth, there is laid a pellucid membrane, which contains a fluid, has the nerves expanded upon it, and is the true vestibule and semicircular canals; while the bony case, which we have described, is merely the mould of these and the support of their delicate texture.*

The COCHLEA, one of the three divisions of the labyrinth, is but imperfect in birds, when compared with that part of the organ in quadrupeds and in man. The cochlea in birds consists merely of two cylinders, formed of cartilage, which are united toward their further extremity. While the opposite extremities diverge, and while one of these cylinders opens into the vestibule, the other opens outward into the cavity of the tympanum.†

That which more than any other circumstance distinguishes the organ of birds from that of animals inhabiting the waters, is the want of the bone or stony concretion in the sacculus vestibuli.



CHAP. IV.

OF THE HUMAN EAR.

THE anatomy of the human ear will naturally be considered under three heads: the external ear; the tympanum; and the labyrinth. The OUTWARD EAR requires no definition.—From the outward ear there is a cartilaginous tube, which leads into the tympanum. The TYMPANUM is the cavity within

* I lately, by accident, drew out the sacculus vestibuli and semicircular canals from the bony part of the ear of a bird, and I found the membranous semicircular canal to consist apparently of the same pellucid elastic matter with those of fishes.

† We find Mr. Home saying that the cochlea is neither absolutely necessary to fit the organ to be impressed by sounds communicated through the air, nor to render it what is termed a musical ear; and that this is sufficiently proved by that part being wanting in birds, whose organ is particularly adapted to inarticulate sounds. That the cochlea is not necessary to the communication of sound through the atmosphere, we have seen from the examination of the ear of the reptile. But since we see that it forms part of the labyrinth in birds, we may be led to doubt Mr. Home's conclusion.

which is placed that mechanism of bones and muscles which increases the strength of the vibration, and conveys it inwards to the labyrinth. The LABYRINTH is the general name of those intricate canals which contain the expanded nerve, and the immediate seat of the organ.



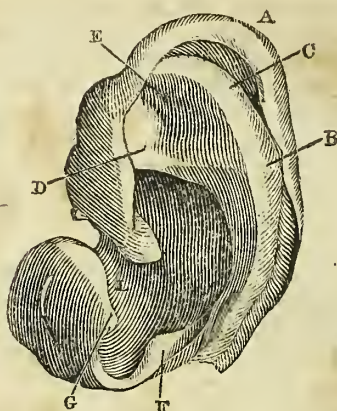
SECTION I.

OF THE EXTERNAL EAR.

The EXTERNAL EAR is formed of an elastic cartilage, covered with very thin integuments. The apparently irregular surfaces of the outer ear will be found, upon examination, to be so formed that the sinuosities lead gradually into each other, and finally terminate in the concha or immediate opening of the tube of the ear. By the constant motion of the external ear of quadrupeds, we see its importance to them, both in collecting sound, and in judging of its direction. In most men, the motion of the ear is lost, but some men still retain it; and this is very remarkable, that when the more internal mechanism of the ear is injured, and ceases to strengthen the sound before it conveys it inwards to the labyrinth, the external ear resumes the office to which it was originally adapted, and by a degree of motion and erection, assists the hearing. In Europeans, the outward ear is in a great degree flattened to the head by the dress; but in Eastern nations, and in ancient statues, we see the ears stand prominent, and bear a part in the symmetry and expression of the whole head. The muscles moving the cartilages, besides being intended to give motion, appear to have a more essential use in giving a due tension to the outward ear. These cartilages are surrounded with their peculiar perichondrium; but as to their vessels and nerves, it seems very superfluous to give a minute description of them here.

When the cartilages are dissected, they appear thus :

Fig. 18.



A. The **HELIX**. It is the outer margin, the edge of which is turned over and forms the *cavitas innominata*.

B C D. The **ANTHELIX**. It is very prominent; of a triangular shape; and within the outer rim or margin.

E. The **SCAPHA**, which is a depression or cavity on the anterior part of the anthelix.

F. The **TRAGUS**.

G. The **ANTITRAGUS**. These are the two prominent points which approach each other, and form the margin of the great cavity of the ear.

L. The **CONCHA**, or great cavity of the ear, and which is the trumpet-like opening of the *meatus auditorius externus*. The few pale-coloured fibres which are found on the cartilages, are scarcely to be recognized as muscles.*

The **LOBE** of the ear, or that part which hangs down and is pierced for the ear-ring in women and savages, consists of skin and cellular substance merely.

The **MEATUS AUDITORIUS EXTERNUS**, is the tube which leads into the tympanum. This tube is partly bony and partly cartilaginous. The outer portion of the tube is cartilaginous, and about three quarters of an inch in length, and is divided by fissures. The internal part of the tube is formed in the bone,

* See Valsalva & Santorini.

as we find upon turning to the description of the temporal bone.

GLANDS OF THE PASSAGE. The cuticle, covering the inside of the tube, is very fine, and there project from it many small hairs which stand across the passage. Under this skin there is a set of small glands, which pour their secretion into the tube, and are called the *GLANDULÆ CERUMENOSÆ*.* These glands, secreting the wax of the ear, have their little ducts opening betwixt the roots of the hairs; and this secretion, with the hairs which stand across the passage, guards the internal parts of the ear from insects. The whole passage, consisting of the long canal of the temporal bone and the cartilaginous tube placed upon it, has an oblique direction. It first passes upward and forward, and then makes a slight curve to descend to the membrane of the tympanum.

This external tube of the ear, being of the nature of a secreting surface, and exposed to the air, is liable to inflammation. There follows a dryness of the passages, and then a more fluid secretion. If the inflammation of the tube should extend within the bones, then, like the affections of all parts surrounded with solid bone, the pain is extreme and the danger considerable: there is not only suppuration in the tympanum and destruction of the *membrana tympani*, but the disease may be still further communicated internally. Hildanus gives us an observation of the effects of a ball of glass dropt by accident into the ear, in which the inflammation was so extensive, and the pain so excruciating, that the whole side of the head and even the arms and leg of that side were affected in consequence of the brain partaking of the inflammation. Such things as peas and cherry-stones and pins are very apt to be put into the ear by children; and awkward attempts to extract the foreign body, very often push it further in; and acrid fluids put into the ear to kill insects, have forced them deeper, with such an increase of pain as has thrown the patient into a condition little short of delirium. A defective or too profuse secretion from the glands of the tube, will cause a degree of deafness: and sometimes the wax is so indurated as to cause a very obstinate deafness.†

* "Hæ figuram obtinent variam: major tamen harum pars vel ad ovalem, vel ad sphericam accedit colore tinguntur flavo ab humore in earum folliculis contento qui ob assiduum fibrarum carnearum reticularium pressionem, per cutis correspondentia foramina in meatus auditorii cavitatem transmittitur." Valsalva de aure humana, p. 10.

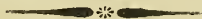
† See Valsalva, p. 10. "Talis funditalis a duodecim annis assilentis curatio." The older writers treat of the "Auditus læsio a fordibus aurium lapidescentibus." See Bonetus, & Jul. Cassertus Placantinus, "De auditus organo," lib. 1. cap. 20. p. 90. There is also mention made of an adventitious membrane, closing up the passage

In the fœtus, the concha and meatus externus are narrow, and there is secreted a thick white stuff, which defends the membrane of the tympanum from the contact of the waters of the amnios. This, after birth, falls out in pieces along with the secretion of the wax; but in some instances, it has remained and become very hard. The deafness from birth, caused by this accident, is often thought to depend upon an organic defect, and so is neglected.



SECTION II.

OF THE TYMPANUM OR MIDDLE CAVITY OF THE EAR, AND ITS DISEASES.



THE ANATOMY OF THE TYMPANUM.

IN the fœtus, the cavity of the tympanum is superficial, compared with that of the adult; for what forms a tube in the latter, is in the former merely a ring, which is attached to the squamous portion of the temporal bone: * upon this circular bone the membrane of the tympanum is extended.

The cavity of the tympanum is very irregular; intermediate betwixt the membrane which is extended across the bottom of the external tube and the labyrinth or internal ear. It contains no fluid, as the labyrinth does; but is really a cavity, having a communication with the external air through a tube which leads into the fauces. The tympanum communicates also backwards with the cells of the mastoid process. † The inner extremity of the meatus externus forms a circle which is pretty

and stretched above the membrana tympani. This is produced by a fœtal secretion, and resembles that which stuffs up the passage in the fœtus. See FABRICIUS de Chirurg. operat. cap. de aur. Chirurg. VESLINGIUS Anat. cap. 16. See Experiments on the solvents of the Ear-wax, by Dr. Haygarth, Med. Obs. and Inquiries, vol. iv. p. 198. He gives the preference to warm water over every other solvent.

* See plate 8. fig. 3.

† When Valsalva, in a case of ulceration and caries on the mastoid process, threw in his injections, he found them flowing out by the mouth: viz. by the eustachean tube through the tympanum. See Val. de aure humana, p. 89.

regular, and upon which the membrane of the tympanum is extended. That part of the cavity of the tympanum which is opposite to the termination of the meatus externus, is very irregular. It has in it the foramen rotundum and the foramen ovale; and betwixt these, there is an irregular bony tuberosity from which there stretch back some exceedingly small spiculæ of bone, which connect themselves with the margin of the irregular cavity of the mastoid process.

The FORAMEN OVALE* is in the bottom of a deep sinus; it is not strictly of an oval form, but has its lower side straight, while the upper margin has the oval curve. This opening leads into the vestibule or central cavity of the labyrinth.

The FORAMEN ROTUNDUM is more irregular than the oval hole. It does not look directly forward, like it, but enters on the side of an irregular projection: it does not lead into the vestibule, but into one of the scalæ of the cochlea. In the recent state of the parts, the periosteum covering the surface of the cavity of the tympanum, takes away much of its irregularity. Where the tympanum leads backward into the CELLULÆ MASTOIDEA, this periosteum is also continued.

THE EUSTACHEAN TUBE† extends forward from the cavity of the tympanum, and opens behind the palate.‡ In the dry bones, the eustachean tube is more like an accidental fissure, than a regular passage, essential to the æconomy of the ear. It appears thus irregular in the bones from the tube being towards the back of the nose, composed of membrane and cartilage; as the tube approaches the opening behind the palate, it widens into a trumpet shape; and the soft extremity of the tube is governed by muscular fibres.

There can be no doubt that the eustachean tube is designed for admitting the free access of air into the cavity of the tympanum, that, by preserving a due balance betwixt the atmosphere and the air contained within the ear, the motion of the membrane of the tympanum may be free. This, at least, we know, that, when the extremity of the eustachean tube is closed, we suffer a temporary deafness, which can be accounted for only by the confined air wanting a due degree of elasticity to allow the vibration of the membrane of the tympanum. I conceive it to be necessary, that the air in the tympanum be changed occasionally, which is, perhaps, accomplished by some actions of the throat and fauces forcing a new body of air into the eustachean tube. The extremity of the eustachean

* Fenestra ovalis.

† Iter a palato ad aurem.

‡ By some older writers, the eustachean tube is called aqueduct, because they conceived that humours were evacuated from the tympanum by this passage.

tube, next to the throat, may be temporarily obstructed by the cynanche tonsillaris, which is frequently attended with pain, stretching from the throat to the ear; or it may be closed by inflammation and adhesion of its mouth, by adhesion of the soft palate to the back of the fauces, by polypus in the nose, reaching down into the fauces and compressing it.*

OF THE MEMBRANA TYMPANI.

The membrane of the tympanum is extended over the circular opening of the bottom of the meatus externus. It has a little of an oval shape, and lies over somewhat obliquely, so that its lower margin is further inward than the upper. Its use is, to convey the vibrations or oscillation of the atmosphere, collected by the outer ear, inwards to the chain of bones in the tympanum. Although this membrane be tense, it is not stretched uniformly like the parchment of a drum, but is drawn into a funnel-like shape by the adhesion of the long process of the malleus to its centre. It consists of two layers of membrane, and has, naturally, no perforation in it; and the experiments of air and the smoke of tobacco sent from the mouth through the ear, succeed only in those who have had the membrane of the tympanum partially ruptured or eroded by ulceration. This membrane is transparent; and when we look into the tube of the ear, and direct a strong light into it, we observe it to be of a shining tendinous appearance.

The inner lamina of the membrana tympani is very vascular. It has, indeed, been said to resemble the iris, both in its profusion of vessels, and in the manner of their distribution.† This is carrying the conceit of their analogy too far. I have observed an artery of a very large size, (compared with the surface to be supplied,) running by the side of the long process or handle of the malleus. In this course, it is giving out small branches; and when the trunk arrives at the extreme point of the long process of the malleus, it divides into two considerable branches, the extreme subdivisions of which run towards the margin of the membrane. This artery is, nevertheless, too small to require us particularly to avoid it in the

* The following case is from Valsalva:—"Quidam plebeius ulcus gerebat supra uvulam in sinistra parte, quod quidem eam, quam invaserat, partem exegerat atque abstulerat sic. ut ulceris cavitas cum extremo sinistrae tubæ orificio communicaret. Igitur quoties homo mollem turundam remediis imbutam in ulceris cavitatem intrudebat; toties illico sinistra aure evadebat furdus, talisque permanebat toto ex tempore quo turunda in ulcere relinquebatur:" p. 90.

† See Mr. Home's lecture on the structure and use of the membrana tympani. Phil. Transact. Part. I. 1800.

puncturing of the membrane for deafness, produced by obstruction of the eustachean tube.

The opinions regarding the muscularity of the membrane of the tympanum, shall be reserved until we have considered the whole mechanism of the parts in the tympanum.

OF THE CHAIN OF BONES IN THE TYMPANUM.

The vibrations of the membrane of the tympanum are transmitted to the foramen ovale by four moveable bones; the malleus, incus, os orbiculare, and stapes. These bones are named from their shape, and the names assist in conveying an idea of their form. They are so united by articulation and small ligaments, as to form an uninterrupted chain; and, while they transmit the vibration, their mechanism is such, that they strengthen the impulse. They have also small muscles attached to them, by which it is probable, the whole apparatus has a power of adapting the degree of tension to the force of the impulse communicated to the membrane of the tympanum. I conceive that they increase the power of the ear for receiving the weaker sounds, and are, at the same time, a guard to the internal parts, from such violent shocks as might injure the nerve.

How necessary it sometimes is to damp and suffocate, in some degree, piercing sounds, we must all be sensible: and in those who are habitually exposed to the sudden eruption of sound, the susceptibility of the nerve is injured, and they become very deaf. We have, in a late publication, an example of this in blacksmiths, in whom, it is common to find a degree of deafness; and we frequently find old artillery-men quite deaf, from the long practice of their profession.

THE MALLEUS* receives its name from a resemblance to a hammer or mallet: it is, in some degree, like a bludgeon; the great head stands obliquely off from the body of the bone, (if such it may be called,) like the head of the thigh-bone.—Anatomists can scarcely be blamed, if, in describing the processes of this bone, they forget the body. I should consider that part as the body of the bone which stretches down from the circular margin of the tympanum, and is attached to the membrane, or what we should consider as the handle of the mallet. This part of the bone stands at an angle with the head and neck; tapers towards the extremity, and is a little curved down towards the membrane. From the larger end of the body of the bone there stands out an acute process; and

* See plate 9. fig. 1. A.

from the neck attaching the bulbous head to the body of the bone, there stands out a very slender process, which is often broken off. The great head of the bone does not form a regular ball to be socketed in the body of the incus; there are irregularities in the contiguous surfaces of both the bones.

THE INCUS* is the second bone of the chain: it receives its name from its resemblance to the blacksmiths anvil. It more resembles a tooth with two roots. On the surface of the body, it has a depression like the surface of the first molaris. Into this depression of the incus the head of the malleus is received. The shorter of the two processes, and the body of the bone lie on the margin of the circular opening of the tympanum; and the acute point of this process is turned back into the opening of the mastoid cells. The long leg or process of the incus hangs down free into the tympanum,† and has attached to its point the os orbiculare.

The OS ORBICULARE is like a grain of sand, and is the smallest bone of the body: it is a medium of articulation betwixt the incus and stapes.

THE STAPES‡ or stirrup is well named, for it has a very close resemblance to a stirrup-iron; the little head is articulated with the os orbiculare: the arch of the bone is exactly like that of the stirrup-iron, but elegantly grooved within, so as to give lightness to the bone. The base answering to that part of the stirrup-iron upon which the foot rests, is not perforated, nor is it of a regular form, but is flat on one side, corresponding with the foramen ovale. It is this base of the bone which is attached to the membrane stretched over the foramen ovale.

CONNECTION AND MOTION OF THESE BONES.

The malleus hanging on that part which we have called the neck of the bone, has the long handle or body of the bone stretched down upon the membrane of the tympanum. It is, consequently, destined to receive the oscillations of that membrane.

The head of the malleus is so articulated with the incus, that the degree of motion communicated to that bone is much increased.

* See plate 9. fig. 1. B.

† See plate 4. fig. 1. D.

‡ See plate 9. fig. 1. C.



From this scheme, we see, that the head of the malleus is so articulated with the body of the incus, that the centre of motion of the incus is in a line drawn through the centre of its body, and, consequently, that the extremity of the long process, to which we see the os orbiculare and stapes attached, moves through a greater space than that which receives the impulse of the head of the malleus. Thus, a very small degree of motion communicated by the head of the malleus to the body of the incus, must be greatly increased in the extremity of the long process of the incus, and, consequently, this mechanism of the bones essentially assists in giving strength to the vibration which is transmitted inward to the seat of the nerve.

The os orbiculare stands simply as a link of communication betwixt the extremity of the incus and the upper part of the stapes, and its use is evidently to promote the accurate and perpendicular motion of this long lever of the incus upon the head of the stapes: for, if this bone had not been so placed, the motion of the long lever of the incus must have given an obliquity to the impulse upon the stapes. The base of the stapes almost completely fills up the foramen ovale. It is seated on a membrane which is stretched over the foramen.* The stapes, then, acts like a piston on a membrane of much less circumference than that of the membrana tympani. From all which considerations, we may learn how much, and how strongly, the agitation of the air in the outer canal of the ear is increased, before it strikes upon the fluids of the labyrinth.

* Valsalva has the following observation; see page 24. "Olim namque in cujusdam surdi cadavere surditatis causam in eo sitam inveni nempe quod indicata membrana in substantiam osseam indurata, unum continuatum os constituebat cum basi stapedis et margine fenestræ ovalis."

OF THE MUSCLES WITHIN THE TYMPANUM.†

The laxator tympani runs in a fissure of the temporal bone on the outside of the eustachean tube, and is inserted into the long process of the malleus. THE TENSOR TYMPANI‡ runs also by the side of the eustachean tube; it is inserted into the body of the malleus; it is a long and slender muscle. The external or superior§ muscle of the malleus, which is denied by some anatomists to be of the nature of muscle, comes down from the upper part of the tympanum, and is fixed by a small tendon to the neck of the malleus.

THE STAPEDIUS|| is the smallest muscle, and is attached to the smallest bone. It has a small round fleshy belly, taking its origin from the rough side of the tympanum, and is inserted by a small round tendon into the head of the stapes.

As all these muscles are inserted either into the malleus or stapes, and not into the middle bone, it would appear that their operation is chiefly upon the membranes of the tympanum, and of the foramen ovale, through the medium of the bone immediately attached to them.

Mr. Home, in the Philosophical Transactions for 1800, asserts, that the membrana tympani is muscular; that its fibres run from the circumference towards the centre; and that they are attached to the malleus.

But, what is the supposed use of this muscular membrane? Mr. Home says, it is principally by means of this muscle that accurate perceptions of sound are communicated to the internal organ; that it is by means of this muscle that the membrana tympani is enabled to vary its degree of tension, so as to receive the vibrations in the quick succession in which they are conveyed to it. But we have seen, that the tension and relaxation of the membrana tympani is already sufficiently provided; for "the malleus has three muscles by which it is moved; one of them is called the tensor, from its pulling the malleus inward and tightening the membrane of the tympanum; the other two act in an opposite direction, and relax the membrane."* We should naturally suppose this to be sufficient; but, according to Mr. Home, these muscles act only to bring the membrane into such a degree of tension, as to enable the minuter

† Musculus processus minimi mallei. Valsalva.

‡ Musculus processus majoris mallei.

§ Musculus processus minoris. Valsalva.

|| This muscle is particularly strong in the horse, where it was first discovered by Casserius.

* Mr. Home's Lecture.

changes of the muscular membrane to have their full effect ; and that the play of these muscles gives the perception of grave and acute tones.

But the more favourite idea of Mr. Home is, that, upon the accurate adjustment of the membrana tympani, the difference between a musical ear, and one which is too imperfect to distinguish the different notes in music, depends ; that this judgment or taste is owing to the greater or less degree of nicety with which the muscles of the malleus render the muscular membrane capable of being truly adjusted ; if the tension be perfect, all the vibrations produced by the action of the radiated muscle will be equally correct, and the ear truly musical.

Mr. Home proceeds upon the idea, that the membrane of the tympanum is like a musical instrument, or, as he expresses himself, like a monochord ; but he is fundamentally wrong in supposing, that it requires a more delicate organ to be perceptible of musical tones than of articulate sounds or language.

In the first place, we may require an explanation of the use of that muscle which is inserted into the stapes. This stapedius muscle would seem to have the same use, and to affect that bone in the same manner, in which the muscles of the malleus affect it. Surely Mr. Home will not go so far as to say, that the membrana fenestræ ovalis is also muscular. It may be further worthy of attention, in considering this subject, that whatever affects the membrane of the tympanum, affects, also, the membrane of the vestibule ; that, if the one be relaxed, the other is rendered tense, from the close connection that exists between them through the chain of bones.

In the paper already quoted, the following case is given, as illustrating the manner in which the loss of the natural action of the muscles affects the ear, in regard to its capacity for music. A gentleman, thirty-three years of age, who possessed a very correct ear, so as to be capable of singing in concert, though he had never learned music, was suddenly seized with a giddiness in the head, and a slight degree of numbness in the right side and arm. These feelings went off in a few hours, but on the third day returned ; and for several weeks he had returns of the same sensations. It was soon discovered that he had lost his musical ear ; he could neither sing a note in tune, nor in the smallest degree perceive harmony in the performance of others. For some time, he himself thought he had become a little deaf, but his medical attendant was not sensible of this in conversation. Upon going into the country, he derived great benefit from exercise and sea-bathing.

In this case, continues Mr. Home, there appeared to be some affection of the brain, which had diminished the action

of the tensor muscles of the membrana tympani, through the medium of the nerve which regulates their actions; this gradually went off, and they recovered their action.

Another case is given of a young lady who was seized with a phrenzy which lasted several years, when, from being without a musical ear, she came to sing with tolerable correctness, to the astonishment of her friends.

Now, to me, the symptoms of both cases argue an affection of the brain, and of the nerves. It is more probable that the delicate auditory nerve should be affected in such a disease, than that the portio dura should be affected.

We now proceed to put the incorrectness of this reasoning concerning the muscular power of the membrane of the tympanum, in a more particular point of view. Mr. Cooper was led to pay particular attention to the action of the membrane of the tympanum, from being consulted in a case where the membrane was lost with little injury to the function of the organ.* He found, that, instead of the total annihilation of the powers of the organ, the gentleman was capable of hearing whatever was said in company, although the membrane of both ears was destroyed. He could even hear better in the ear in which no traces of the membrane remained. This gentleman was only in a small degree deaf from the loss of the membrane; but his ear remained nicely susceptible of musical tones, "for he played well on the flute, and had frequently borne a part in a concert; and he sung with much taste, and perfectly in tune." This case puts aside, at once, that theory

* Case. This gentleman had been attacked at the age of ten years, with an inflammation and suppuration in his left ear, which continued discharging matter for several weeks: in the space of about twelve months after the first attack, symptoms of a similar kind took place in the right ear, from which matter issued for a considerable time. The discharge, in each instance, was thin, and extremely offensive to the smell; and in the matter, bones, or pieces of bones, were observable. The immediate consequence of these attacks was a total deafness, which continued for three months; the hearing then began to return; and, in about ten months from the last attack, was restored to the state in which it at present remains. Having filled his mouth with air, he closed the nostrils, and contracted the cheeks; the air thus compressed, was heard to rush through the meatus auditorius with a whistling noise, and the hair hanging from the temples became agitated by the current of air which issued from the ear. When a candle was applied, the flame was agitated in a similar manner.

Mr. Cooper then passed a probe into each ear, and he thought the membrane on the left side was entirely destroyed, since the probe struck against the petrous portion of the temporal bone. The space usually occupied by the membrana tympani, was found to be an aperture without one trace of membrane remaining. On the right side, also, a probe could be passed into the cavity of the tympanum; but here, by conducting it along the sides of the meatus, some remains of the circumference of the membrane, could be discovered, with a circular opening in the centre, about the fourth of an inch in diameter. See *Trans. Roy. Soc.* for 1806, Part. I. p. 151.

which supposes the musical ear to depend on the minute play of the muscles of the tympanum.

It appears, then, that the membrane of the tympanum may be destroyed, that the bones may be washed out by matter formed in the tympanum, and still the patient retain the use of the organ. But this is only while the stapes retains its place; for, if this bone be also destroyed, the membrane of the foramen ovale will be destroyed, and the fluids of the labyrinth be allowed to flow out, or be otherwise lost. We see, that, if the chain of bones, and only a part of the membrana tympani be left, still this shred of membrane, if it be not detached from the handle of the malleus, will vibrate in the air, and communicate those vibrations through the other bones to the vestibule. We see, also, that though the bones only remain, and though they be detached from the membrane of the tympanum, the sound will still be communicated. We see, that a rupture of the membrane will not destroy the organization so far as to prevent the hearing, unless there follow clots of blood or inflammation, suppuration, or fungus. When Mr. Cooper found that the membrana tympani could be torn without injuring the organ, he did not stop short in his investigation: but as he found, by daily experience, that obstruction of the eustachean tube caused deafness, he thought of puncturing the membrana tympani, as a cure for that kind of deafness. He expected, by this operation, to give elasticity to the confined air. Accordingly, by puncturing the membrane of the tympanum with a small trocar, he found, with much satisfaction, that the hearing was instantly restored.*

Valsalva made a good distinction, when he said, that the membrane of the tympanum was not absolutely necessary to hearing, but only, to perfect hearing. We have, in this fact, the explanation of the following circumstance, amongst many others: "In naturali surditate a conformationis vitio inter tandum istud experimentum, (viz. an ossiculi et membrana tympani aliquis sit usus auditum,) quod inopinato et feliciter successit cuidam, qui intruso auri scalpio in aurem profundissime disruptit tympanum, fregitque ossicula et audivit." *Biolanus Encherid. Anat. lib. 4. c. 4.* See also *Bonetus de Aurium Affect. Observ. IV.* Willis also knew, that the destruction of the membrana tympani did not deprive the person of hearing. *Vid. de Anima Brutorum.*

* I am only afraid that such punctures will not continue open, as in Valsalva's experiments they healed up very soon. But, when there is no other ingress and egress to the air in the tympanum, but through the punctured hole, it may tend to keep it open.

§ 2. OF THE DISEASES OF THE TYMPANUM.

Valsalva denied the existence of periosteum to these bones of the tympanum, while he allowed that they had minute vessels distributed on their surfaces: but these vessels he supposed to creep along the naked bone independently of any membrane. This, however, is contrary to all analogy. These bones, as well as the cavity of the tympanum, are covered with a very fine membrane or periosteum, which, after a minute injection, is seen covered with many small and distinct vessels, as well as with intermediate extravascular effusions of the injection, as happens in injecting in other membranes.

When the tympanum becomes diseased, there is fetid matter collected, the membrane of the tympanum suffers, and the small bones are sometimes discharged. In such a case, we have little farther to do than, by injections, to prevent the matter from accumulating. But, let us not confound this serious cause of deafness with the slighter suppurations in the outer passage of the tube: although such suppurations in the tube of the ear are apt, when neglected, to destroy the membrane of the drum or tympanum, and to spread disease to these internal parts.

Authors make a display of the diseases of the membrane of the tympanum under the titles *relaxatio*, *tensio*, *nimia*, *induratio*, and *diruptio tympani*.* We have seen how little rupture of the membrane affects the hearing, and may thence conclude, that these fantastic imaginings about tension and relaxation of the membrane deserve little notice. The idea of relaxation of the membrane of the tympanum, I have no doubt, has arisen from the effect of cold and moist weather in injuring the hearing; but deafness from this cause is not produced by relaxation of the membrane of the tympanum, but by swelling of the mouth of the eustachean tube.†

Induration of the membrane is less of an imaginary disease, since there are instances of the membrane becoming thickened by inflammation, or cartilaginous, or osseous. The *membrana tympani* has been found to adhere to the extremity of the

* *Sec Du Verney de Organo Auditus. p. 41.*

† “*Relaxatio fit ab humore superfluo qui membranam hanc humectat et symptoma hoc communiter cum obstructione meatus ex tumore glandularum conjunctum est, de qua jam supra dictum est: multum autem facit ad difficultatem audiendi in personis quæ defluxionibus catarrhosis obnoxie sunt et per eandem rationem aultri nebulae et aer pluvius auditum minuunt ut experiri quotidie possumus.*” *Du Verney loc. cit. p. 41.*

incus.* Independently of the want of elasticity, which such an adhesion must produce, the mechanical effects, the vibration of the bones, is prevented, and a degree of deafness is inevitable.

Fungous or polypous excrescences from the glands in the outer passage of the ear, press back and destroy the membrane of the tympanum. In the cure of these by the knife, caustic, or ligature, there is much danger of injuring the membrane.—Fungous tumours project from the membrane itself. A stroke upon the head will cause bleeding from the ear. This is often a sign of concussion of the brain; that is to say, a shock so severe as to rupture the membrane of the tympanum, will most probably injure the brain,† after bleeding from the ear. Sometimes suppuration follows;‡ and blood flowing thus from the membrane of the tympanum, or other part of the ear, runs back into the cavity of the tympanum, and, filling it with coagulum, causes deafness, by obstructing the free motion of the bones and membrane. Mr. Cooper, in a case of this kind, punctured the membrane, and, after a discharge of blood which continued for ten days, the hearing was gradually restored.—It is supposed by that gentleman, that the blood effused becomes, in some instances, organized, so as to obliterate the tympanum, causing permanent deafness. I think it is more likely that the blood has, in such cases, destroyed the mechanism by suppuration.

The danger in suppuration and caries of the tympanum is, that the disease may penetrate backward into the mastoid cells and labyrinth, or into the brain itself; for inflammation and suppuration so confined amongst the deep recesses of the bone, must give great torture, and be apt to extend the mischief to the brain, or throw out matter on the inside of the cranium, the effect of which must be mortal. Such, I think, I have seen to be nearly the effect of suppuration deep in the ear. In a man who had been deaf for many years, and who was killed by a fracture of the skull, I found the cells of the temporal bones filled with matter, and a thin greenish fluid lay betwixt the temporal bone and dura mater.

Valsalva gives us a case of injury of the head, in which the patient was relieved while the discharge of pus by the ear was free; but he died when it was entirely suppressed.§

* See the London Philosophical Transactions for 1800. Part I. p. 5.

† When Valsalva found the ventricles of the brain full of blood, and blood also in the tympanum, he supposed that the blood in the latter was derived from the brain through certain foramina which he discovered. See p. 30.

‡ See Valsalva, p. 16.

§ Valsalva, p. 83. See also a case in Bonetus de Aurium Affect. Observ. I. and

But, after such suppuration as we should naturally think must totally destroy so delicate an organization, we are sometimes agreeably surprised with a gradual recovery of the function. This is owing to the nerve accommodating itself, or becoming sensible to a less forcible impression, and by the ear acquiring new properties. I already mentioned, that the destruction of the mechanism of the tympanum arose sometimes from suppurations beginning in the outward ear: and we may suppose that the apparatus within the tympanum, when partially hurt, is sometimes capable of being, in some degree, replaced by a natural process; of which, the following case from Valsalva is a remarkable proof.

“ I lately examined the ears of a woman whose hearing had been much injured by an ulcer of the tympanum and caries of the small bone. I found the ear in which she was deaf without a membrana tympani, and the stapes only remaining of the bones, and a fibrous mass, like an excrescence, in the tympanum. But, in the tympanum of the opposite ear, I found the membrana tympani almost entirely eroded; so that the malleus and incus were uncovered, and distinctly seen. I could even observe, that the long process of the incus, which should be articulated with the head of the stapes, was separated from it: but nature had curiously restored the eroded membrane.— Thus, from the edge of the injured membrane, a new membrana tympani was obliquely stretched across the cavity of the tympanum, so as to exclude the malleus and incus from that cavity, but including the head of the stapes, as if nature, finding the separated bones no longer necessary, had attached the membrane to the head of the stapes.* We have already remarked, that, when the organ of one side is injured, we hear so much better with the other, that we attend only to the sensation conveyed by it, and neglect the duller sensation.— The consequence of this is, that the bad ear becomes worse. It is much like that effect which takes place in eyes by squinting.

Gul. Ballonius Epid. et Ephem. lib. 2. p. 270. When the matter was suppressed, there came pain of the head, and weight, which yielded to no remedy; on dissection, there was found an abscess within the skull. In Bonetus loc. cit. a case is related, in which an ignorant surgeon compressed a fistulous ulcer in the ear, and so caused the death of the patient.

* See Valsalva de Aure Humana Tract. p. 79. In those deaf from birth, it has been twice found that the *incus* was wanting. See Bonetus de Aur. Affect. Observ. IV.

SECTION III.

OF THE LABYRINTH.

The labyrinth is the internal ear ; the proper seat of the sense of hearing. It consists of the vestibule or middle cavity ; of the semicircular canals ; and of the cochlea. It has its name from those cavities and tubes leading into each other in so intricate a manner, as to be followed out with much difficulty.

We understand that the cavities hitherto described in the human ear contain air, and communicate with the atmosphere : but, in the cavities we have now to describe, the nerve is expanded, and there is, in contact with it, not air, but an aqueous fluid. In treating of this division of our subject, we have, first, to attend to the forms of the cavities, as seen when sections are made in the dry bones next to the soft parts contained in those cavities ; and, finally, to the distribution of the nerves. To give an idea of the exquisitely delicate and complex structure of the many canals, excavations, openings, sulci and foveæ, of the bones ; of the tubuli, sacculi, and partitions of the membranes ; and, lastly, of the soft expansions of the nerves, without the assistance of plates, would be impossible. Albinus, in his academical annotations, begins very formally a chapter on the ear ; but, after a few words, dismisses the subject, referring merely to his plates.

THE VESTIBULE, or central cavity of the labyrinth, is of an oval form, and about a line and a half in diameter.* It has two remarkable pits or hollows in it, and has numerous foramina opening from it into the neighbouring cavities, besides lesser foramina for transmitting that portion of the nerve which is distributed on the sacs contained in it. One depression or fovea is in the back and lower part of the vestibule, another in the outer and superior part of it : the one is circular, the other semi-oval. Morgagni, and other anatomists, examining the dry bones, speculated on their use in reverberating the sound in the cavity ; but we must not regard them in this unnatural state : on the contrary, they contain in the living subjects membranous sacculi filled with fluid, and have the nerve expanded upon them. That foramen over which the stapes is placed, and which is called the foramen ovale, transmits the vibration into the vestibule. For the foramen ovale opens directly into the vestibule, and through the vestibule, only, does

* Du Verney Œuvres Anatomiques:

the vibration of the bones in the tympanum reach the other parts of the labyrinth.

SEMICIRCULAR CANALS. When we have cut into the vestibule, by taking away that portion of the os petrosum which is behind the meatus auditorius internus, we see five circular foramina: these are the openings of the semicircular canals.— There are three semicircular canals; and they are distinguished by the terms, the superior or vertical, the posterior or oblique, and the exterior or horizontal. The one which, in this view, is nearest, is the opening common to the inner ends of the posterior and superior semicircular canals. When we pass a bristle into this common foramen, and direct it upward, it passes along the superior semicircular canal, and will be seen to descend from the upper part or roof of the vestibule, almost perpendicularly on the foramen ovale, which is open, and immediately opposite. If, again, we pass a bristle into the foramen which is near the bottom of the cavity, (and which will be just upon the edge of the fracture that has laid open the vestibule, if not included in it,) it will come out by the opening common to the superior and posterior semicircular canal. It has passed, then, along the posterior canal. The two openings of the exterior or horizontal canal are upon the back part of the vestibule; and the canal itself takes a circle which brings its convexity to the confines of the mastoid cells. These canals are formed of a very hard brittle bone, their calibre is so small as not to admit the head of a common pin; they form somewhat more than a half circle; and of each of them, one of the extremities is enlarged like the ampullula of fishes. Valsalva imagined that the enlarged extremities of these tubes were trumpet-like, to concentrate and strengthen weak sounds.— We shall find, on the contrary, that there is in the human ear, as in fishes, a particular expansion of the nerve in these extremities of the tube, opposed to the circulatory vibration of the fluids in the canals.

THE COCHLEA. The third division of the labyrinth is the cochlea. It is so named from its resemblance to the shell of a snail, or from the manner in which its spiral lamina turn round a centre like a hanging stair. It has been minutely, but not simply, described: and, indeed, there can be nothing more difficult, than to describe it in words.

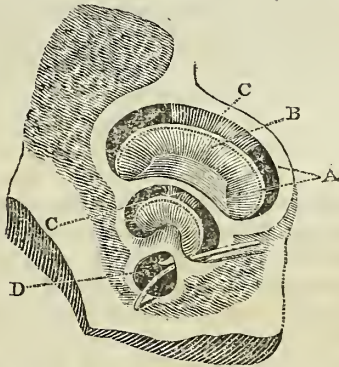
When the os petrosum is cut from around the cochlea, it is seen to be of a pyramidal shape, and to consist of a scroll, making large circles at the base, and gradually lesser ones towards the apex. It is formed in the most anterior part of the petrous bone, and has its apex turned a little downward and

outward ; and the base is opposed to the great cul de sac of the internal meatus auditorius.

The spiral tube, of which the cochlea is composed, forms two turns and a half from the basis to the point ; and it consists of the same hard and brittle matter with the semicircular canals. When the whole cochlea is cut perpendicularly in the dry state of the bones, and when the membranes have shrunk away or spoiled, the sides of the spiral canal appear like partitions, and are, indeed, generally described as such. In consequence of the spiral tube of the cochlea having its sides cut perpendicularly, the cochlea appears as if divided into three circular compartments or successive stages ; but there is really no such division ; because the spiral turnings of the tube lead from the one into the other.

Fig. 19.

Cochlea.



A. *Scalæ*——B. *Lamina Spiralis*.
C. C. *Modiolus*.—D. *Infundibulum*.

What gives particular intricacy to the structure of this part of the labyrinth, is the *LAMINA SPIRALIS*. This spiral partition runs in the spiral tube of the cochlea, so as to divide it in its whole length ; and, in the fresh state of the parts, this lamina of bone is eked out by membrane, so as to form two perfectly distinct tubes. These tubes are the *SCALÆ COCHLEÆ* ; they run into each other at the apex of the cochlea ; but at the base, the one turns into the vestibule, and the other opens into the tympanum by the *FORAMEN ROTUNDUM* ;

In the middle of the cochlea there runs down a pillar, which is the centre of the circumvolutions of the scalæ. It is called the MODIOLUS. This pillar is of a spongy structure; and through it the nerves are transmitted to the lamina spiralis, and sides of the cochlea.

The modiolus opens towards the apex of the cochlea like a funnel; and when we take away the outward shell of the apex of the cochlea, which is called the CUPOLA, we look into this expansion of the upper part of the modiolus as into a funnel; it is therefore called the INFUNDIBULUM. The infundibulum is that part which, in a perpendicular section, we should call the upper partition.*

The scalæ or divisions of the spiral tube of the cochlea, have a communication at their smaller extremities in the infundibulum; and as, again, their larger extremities do not open into the same cavity, but one into the vestibule, and the other into the tympanum, the vibrating motion, which is communicated through the cochlea, must pass either from the tympanum into the foramen rotundum, circulate round the modiolus by the scala tympani, pass into the lesser extremity of the scala vestibuli in the infundibulum, and circulate through it towards the base of the cochlea, until it pass into the vestibule; or it must pass from the scala vestibuli into the scala tympani. The first is the opinion of Scarpa and others. But I trust it will afterwards appear, that the oscillations of sound are in the first place conveyed into the vestibule, and thence circulate round both the semicircular canals and cochlea.

In the dry bones, when we cut into the cochlea, there appears a spiral tube, as I have described; with a partition running along it, and, of course, taking the same spiral turns with it towards the apex. This is the bony part of the lamina spiralis; but, as the membrane which extends from its circular edge quite across the spiral tube of the cochlea, has shrunk and fallen away in the dry state of the parts, the lamina spiralis is like a hanging stair, and the scalæ are not divided into distinct passages. In this bare state of the shell of the cochlea, when we cut away the cupola or apex of the cochlea, and look down upon the infundibulum, we see the extreme point of the lamina spiralis rising in an acute hook-like point.

The modiolus or central pillar, and the lamina spiralis which encircles it, are of the most exquisite and delicate structure; for, through them the portion of the seventh nerve destined to the cochlea is conveyed. To say that the modiolus is formed of two central bones, is saying that there is no central column

* That is supposing the cochlea to rest on its base.

at all ; or, that the modiolus is the cavity seen in the bottom of the meatus auditorius : and to affirm, at the same time, that the modiolus is a nucleus, axis, or central pillar, is a contradiction in terms.

When we break away the shell of the cochlea, and break off, also, the spiral lamina, we find the little funnel-like depression in the bottom of the meatus internus reaching but a little way up into the centre of the cochlea.—We find this depression of the meatus auditorius internus perforated with innumerable small holes ; and these foramina are so placed as to trace a spiral line, because they give passage to the nerves going to the spiral lamina, and must take the form of the diminishing gyrations of the lamina spiralis. In the centre of these lesser foramina, which are seen in the bottom of the great foramen auditorium internum, there is a hole of comparatively a large size, which passes up through the middle of the pillar. The modiolus is formed of a loose spongy texture, and resembles the turns of a cork-screw ; and this spiral direction is a necessary consequence of the lamina spiralis, being a continuation of the spongy or cribriform texture of the modiolus.

INTERNAL PERIOSTEUM OF THE LABYRINTH. We find that the vestibule, the semicircular canal, and cochlea, besides their soft contents, which we have yet to describe, have their proper periosteum, which, after a minute injection, appears vascular ; and this, as it has appeared to me, is particularly the case with the last mentioned division of the labyrinth. I see very considerable vessels distributed on the vestibule ; particularly, I see their minute ramifications on the circular fovea, while very considerable branches are seen to course along the semicircular canals. In the cochlea, I see distinct branches of vessels rising from the root of the lamina spiralis, and arching on the scalæ, to the number of ten in the circle ; and, after a more minute injection, I have found the osseous part of the lamina spiralis tinged red, and the membranous part of a deep scarlet.*

We have observed the **MEATUS AUDITORIUS INTERNUS** to be a large oval foramen in the posterior surface of the pars petrosa of the temporal bone. This tube transmits the seventh or auditory nerve. It is about five lines in diameter, but increases as it passes inward ; and appears to terminate in two deep fovea, which are divided by an acute spine. But the auditory foramen only appears to terminate in these fovea, for they are

* In a preparation before me, I see a considerable artery derived from the basilar artery, and entering the meatus auditorius internus. From this trunk, I conceive that most of these arteries which I have described, are derived.

each perforated by lesser holes, which lead into the three divisions of the labyrinth, whilst a larger one conveys a portion of the nerve through the cavities of the temporal bone altogether, and out upon the side of the face. This larger foramen is in the upper part of the superior and lesser fovea. It first ascends to near the surface of the petrous part of the temporal bone,* and then descends and turns backward and takes a course round the tympanum above the foramen ovale; and close by the posterior semicircular canal. Its termination is the foramen stylo mastoideum.† Where this canal of the portio dura advances towards the surface of the pars petrosa, it is joined by a very small canal which extends from the vidæan hole on the fore part of the inclining face of the bone: again, after it has passed the tympanum, it is joined by a short canal which receives the corda tympani, after it has passed the tympanum.

The other foramen which is in the upper and lesser fovea of the meatus internus, is rather a cribriform plate, as it is a deep pit with many foramina in it. These lead into the vestibule, and form the *MACULA CRIBROSA VESTIBULI*.‡ In the inferior and larger fovea, we observe several dark spots, which, when more narrowly examined, are also distinguished to be cribriform plates, or collections of lesser foramina. We particularly observe that conical cavity which is perforated with many little pores for transmitting the nerve into the cochlea, and which we have already mentioned. From the form which these foramina take, this is named the *TRACTUS SPIRALIS FORAMINOSUS*. These foramina, after passing along the modiolus cochleæ, turn at right angles, and pass betwixt the plates of the lamina spiralis.

Besides the tractus spiralis foraminolosus, the bottom of the larger fovea has many irregular foramina, which are like cancelli: for very delicate speculæ of bone stand across some of them. There is a range of these foramina which stretches from the tractus spiralis. This may properly be called the *TRACTUS CALTHRATUS RECTUS*;§ they do not lead into the vestibule, but into the beginning of the lamina spiralis, where it divides the two scalæ cochleæ, and turns the orifice of one of them, (by a beautiful curve,) out into the tympanum.

Nearer to the ridge which divides the two foveæ of the meatus internus, there is a little pit which has also a cribriform plate (like that which is in the upper fovea, and is called ma-

* In the fœtus, it becomes here superficial.

† This is the aqueduct of Fallopius.

‡ See Scarpa, Plate VII. fig. i, m.

§ *Tractus spiralis foraminulosi initium.* Scarpa.

cula cribrosa;) opposite to this point, the inside of the vestibule is rough and spongy: it transmits a portion of the nerve to the sacculus in the hemispherical sinus of the vestibule.*

OF THE SOFT PARTS CONTAINED IN THE LABYRINTH.

Within the vestibule, semicircular canals, and cochlea, there are soft membranes independent of the periosteum. These form sacculi and tubes which contain a fluid, and have the extreme branches of the portio mollis distributed among them. Betwixt the soft and organized sacculi and tubes, and the periosteum of the osseous labyrinth, a watery fluid is exuded.

SACculus VESTIBULI. The hemispherical and semi-elliptical foveæ which we have described in the vestibule, contain, or at least receive partially, two sacculi. The sacculus which is in the hemispherical cavity, receives the most convex part of the sacculus vestibuli. This sac is distended with a fluid, and is pellucid, and fills the greater part of the vestibule; for only a part of it is received into the fovea. It forms a complete sac, and has no communication with the other soft parts of the labyrinth, though lying in contact with the *alveus communis*, presently to be mentioned; and being surrounded with an aqueous fluid, it must receive the impressions of sound in common with them.

ALVEUS COMMUNIS DUCTUUM SEMICIRCULARUM. This sacculus lies in the semi-elliptical fovea of the vestibule, or, like the other sacculus, is in part received into it. This sacculus receives the extremities of the *tubuli membranacei* which lie in the semicircular canals; it is a little bag common to them, and connecting them altogether, as in fishes: it is filled with fluid, and is so pellucid, as to be distinguished with much difficulty.† Upon pressing the common sac, or the *ampullulæ* of the semicircular canals, the fluids are seen to circulate along the membranous tubes of the canals. These two sacculi in the vestibule lie together, and firmly adhere, but do not communicate; yet, (as may be easily imagined,) they cannot be separated without tearing the partition.

TUBULI MEMBRANACII. The *tubuli membranacii* are the semicircular tubes which pass along the osseous semicircular canals, and to which the latter are subservient, merely as supporting them. They are connected by means of the common

* Scarpa.

† Proprio humore turgidus adeo translucet ut ablongum bullulam aëream mentiatur. Scarpa, p. 47.

alveus in the vestibule, and form a distinct division of the organ.

It was believed by anatomists formerly, that the osseous canals had the pulp of the nerve expanded on their periosteum. But we find, on the contrary, that the membranous tubuli do not touch the bones, but are connected with them by a transparent cellular membrane-like mucus. Each of the semicircular membranous tubes has one extremity swelled out into an ampulla of an oval form, answering to the dilated extremity of those osseous tubes which we have already described.—These ampullæ have the same structure and use with those formerly mentioned in describing the ear in fishes. When the central belly of these tubes is punctured, both the ampullæ and the membranous canals fall flaccid.

Besides those vessels which we have described running along the periosteum of the cavities of the labyrinth, vessels also play upon the sacculi and membranous tubes. The ampullæ of the tubes are, in a particular manner, supplied with blood-vessels.*

In the COCHLEA there is also a pulpy membrane, independent of the periosteum; but of this I can say nothing from my own dissection.



SECTION IV.

OF THE NERVE.

As the seventh pair of nerves arises in several fasciculi, they form what would be a flat nerve, were it not twisted into a cylindrical form, adapted to the foramen auditorium internum. While these fasciculi are wrapped in one common coat, they are matted together. In the canal, the nerve is divided nearly into two equal parts; † to the cochlea and to the vestibulum and semicircular canals. Those fasciculi, which are destined for the vestibule, are the most conspicuous; and on the portion

* “Caeterum univcrsum hoc canaliculorum membræorum alveique communis machinamentum, sanguiferis vasis instruitur, quorum crassiora, circum alveum commune, serpentino incessu, ludunt; crebra et conferta alia ampullæ imprimis recipiunt ob quam causam rubellæ plerumque sunt et cruore veluti suffusæ.”—Scarpa, p. 47.

† Of the portio dura we have already spoken.

destined for the ampullæ of the superior and external canal, there is formed a kind of knot or ganglion.

Before the auditory nerves pass through the minute foramina in the bottom of the meatus auditorius, they lay aside their coats and become more tender and of a purer white colour ; and, by being still further subdivided by the minute branching and divisions of the foramina, they cannot be followed, but finally expand in a white pulpy-like substance on the sacs and ampullæ. We must, however, recollect that there was a difference to be observed in the apparent texture of these expanded nerves in the lower animals : we may observe here, also, that part of the nerve which is expanded on the common belly or sacculus tubulorum, is spread like a fan upon the outer surface of the sac, and has a beautiful fibrous texture ; but upon the inside of the sac, upon which it is finally distributed, it loses the fibrous appearance. We must suppose its final distribution to be in filaments so extremely minute, that we may call it a pulp ; though by the term it must not be understood that an unorganized matter is meant.

That part of the nerve which stretches to the ampullæ, immediately divides into an opaque white mucous-like expansion. Beyond these ampullæ, there has been no expansion of the nerve discovered in the membranous tubes.

The sacculus vestibuli* is supplied by a portion of the nerve which perforates the macula foraminulosa in the centre of the osseous excavation, or that which receives into it part of the sac. This part of the nerve is expanded in a soft mucous-like white matter in the bottom and sides of the sac.

A division of the nerve, as we have already explained, passes from the meatus auditorius internus through the cribriform base of the modiolus into the cochlea. Owing to the circular or spiral form of the foramina when the nerve is drawn out from the meatus, its extremity appears as if it had taken the impression of these foramina from the extremities of the torn nerves preserving the same circular form. These nerves, passing along the modiolus and scalæ cochleæ, are in their course subdivided to great minuteness. Part of them perforate the sides of the modiolus, whilst others pass along betwixt the two plates of the lamina spiralis, and out by the minute holes in the plates and from betwixt their edges. Lastly, a central filament passes up through the centre of the modiolus, and rises through a cribriform part into the infundibulum to supply the infundibulum and cupola.

* i. e. In opposition to the sacculus tubulorum.

Where the nerves pass along the lamina spiralis, their delicate fibres are matted together into a net-work. According to the observations of Dr. Monro, they are quite transparent on their extremities.



CHAP. V.

OF HEARING IN GENERAL.

WHEN aërial undulations were, by the experiments on the air pump, first proved to be the cause of sounds, philosophers looked no further to the structure of the ear than to discover an apparatus adapted to the reception of such vibrations.— When they observed the structure of the membrane of the tympanum, and its admirable capacity for receiving these motions of the atmosphere, they were satisfied, without considering the immediate objects of sensation. In the same way, an ignorant person, at this day, would rest satisfied with the fact that sound was received upon the drum of the ear. But after so minutely explaining the anatomy of the ear, it becomes us to take a general survey of a structure the most beautiful which the mind can contemplate. We cannot say that it surpasses in beauty the structure of other parts of the body: but the parts are adapted to each other, in a manner so simple, efficient, and perfect, that we can better understand and appreciate the harmony of their structure than that of organs, which perform their functions by qualities and actions almost entirely unintelligible to us.

We see that the external ear collects the vibrations of sound at it moves in the atmosphere with circular undulations from the sonorous body: here we may observe, that where the necessities of animals require them to be better provided with this external part of the organ than man, the superiority is only in the simple perception of sound; while man, from the perfection of the internal organ, excels all animals in the capacity of the ear for articulate and musical sounds.

From the external ear we observe, that the trumpet-like tube conveys the sound inward to the membrane of the tympanum.

Behind the membrane of the tympanum, there is a cavity which, in order to allow of the free vibration of the membrane, contains air.—When this air is pent up, by the swelling or adhesion of the eustachean tube, the elasticity of the air is diminished, and the membrane prevented from vibrating.*

In the tympanum, we have seen that the operation of the chain of bones is to increase the vibration received upon the membrane of the tympanum, and to transmit it to the membrane of the foramen ovale. In the cavity of the tympanum we observed two foramina, the foramen ovale and the foramen rotundum, both of which lead into the labyrinth; but one of them (the foramen ovale) into the vestibule, the other (the foramen rotundum) into the scala of the cochlea: now it becomes a question, whether the oscillations of sound pass by one or by both of these foramina?

It is the opinion of many, that while the chain of bones receives the motion of the membrane of the tympanum, the motion of this membrane at the same time causes a vibration of the air in the tympanum which reaches the foramen rotundum, and thus conveys a double motion through the cochlea.

In the labyrinth there is no air, but only an aqueous fluid: now this, we have seen, conveys a stronger impulse than the atmosphere; stronger in proportion to its greater specific gravity and want of elasticity; for an elastic fluid like air may be compressed by concussion, but an inelastic fluid must transmit fairly every degree of motion it receives. But if the fluid of the labyrinth be surrounded on all sides; if, as is really the case, there can be no free space in the labyrinth, it can partake of no motion, and is ill suited to receive the oscillations of sound. Against this perfect inertia of the fluids of the labyrinth I conceive the FORAMEN ROTUNDUM to be a provision. It has a membrane spread over it, similar to that which closes the foramen ovale. As the foramen ovale receives the vibrations from the bones of the tympanum, they circulate through the intricate windings of the labyrinth, and are again transmitted to the air in the tympanum by the foramen rotundum. Without such an opening there could be no circulation of the vibration in the labyrinth; no motion of the fluids communicated through the contiguous sacculi, nor through the scalæ of the cochlea; because there would be an absolute and uniform resistance to the motion of the fluids.—But, as it is, the provision is beautiful. The membrane of the foramen rotundum alone gives way of all the surfaces within the labyrinth, and this

* See *Recherches, &c. relatives a l'organe de l'ouïe & a la propagation des sons*, par M. Perolle, Societ. R. de Medecine, tom. iii.

leads the course of the undulations of the fluid in the labyrinth in a certain unchangeable direction.

To me it appears, that to give a double direction to the motion of the fluids, or to the vibration in the labyrinth, far from increasing the effect, would tend to annihilate the vibrations of both foramina by antagonizing them. The common idea is, that there is a motion communicated through the membrane of the foramen rotundum along the scala tympani, and another through the foramen ovale into the vestibule, and through the vestibule into the scala vestibuli; and that the concussion of these meet in the infundibulum of the cochlea. But as there is no space for motion in the fluids in either the one or other of these tracts, the vibration must have been received in the infundibulum at the same time that the motion was communicated to the membranes of the foramen ovale and rotundum; for if a tube full of water, a mile in length, loses one drop from the extremity, there must be an instantaneous motion through the whole to supply its place. The evident consequence of this double motion would be, (if they were of the same strength) to suppress all motion or vibration in the fluids of the labyrinth.

But we have shown that the strength of vibration communicated to the foramen ovale and foramen rotundum are not the same: for the mechanism of the bones in the tympanum is such as to accumulate a greater force or extent of motion on the membrana ovalis, than is received upon the membrana tympani; therefore the greater vibration which is communicated through the medium of the air in the tympanum, cannot be supposed capable of opposing the stronger vibration which circulates from the foramen ovale through the labyrinth, and returns by the foramen rotundum. Besides, the air in the tympanum has a free egress, and cannot therefore strike the membrane on the foramen rotundum forcibly.

For these several reasons, I conceive that the following account of the manner in which the sound is conveyed is erroneous:—"Et quo ad zonam cochleæ spiralem quoniam altera cochleæ scala in vestibulo patet, altera a FENESTRA ROTUNDA initium sumit, atque carum utraque aqua labyrinthi repleta est, et scalæ in apice cochleæ simul communicant, zona spiralis inter duas veluti undas sonoras media, a tremoribus per vasim stapedis, simulque ab iis per membranam *fenestra rotundæ* advectis utraque in facie percussitur et una cum percussis acoustici nervi per eam distributis contremiscit: quibus porro omnibus, in ampullis videlicet canaliculorum semicircularium, alveo eorum communi, sacculo vestibuli spherico

et lamina cochleæ spirali acoustici nervi affectionibus auditum contineri nemo non intelligit.”*

As to the immediate seat of the sense of hearing, there cannot, after what has been explained regarding the distribution of the nerves, remain any controversy; though before the structure of the ear was so well understood, some imagined that the vestibule, others that the middle part of the semicircular canals, was the seat of hearing; others, again, that the lamina spiralis was better adapted for receiving the vibrations of sound. It is evident that the soft expansion of the nerve, in all the three divisions of the labyrinth, is destined to receive the undulation of the contained fluids, and that this motion of the fluids gives to the nerve, or to the nerve and brain conjointly, the sensation of hearing.

Since we have, in some measure, traced the structure of the ear from the animals of a simple structure to those of a more complicated organization, and have observed some parts of the ear common to all animals, some peculiar to certain orders; and since all have the sense of hearing, more or less acute, it becomes natural to inquire what are the parts of the organ the most essential to the mere perception of sound, and what parts conduce to a more perfect state of the sense.

All the external apparatus of the ear is not necessary to give the animal the simple perception of sound. There are many classes of animals altogether without them, and even in man we see that they are not absolutely necessary; since when deprived of them by disease, man still enjoys the sense. He is deprived of no essential variety of the sensation; he is capable of perceiving the distinctions of articulate sound; and still possesses his musical ear. The external apparatus of the ear, the membrane of the tympanum, the little bones, and even the external ear, only receive, concentrate, and increase the tremors of the external air, and render the slighter impressions audible.

It would appear, that the simple sac of the vestibule is sufficient to receive the impression in some animals, and that in many the vestibule and semicircular canals form solely the organ of hearing. It is evident, therefore, that these are the most essential parts. We see also an intention in the strict similarity of figure and place in these canals through all the varieties of animals, from fishes to man. It would seem to indicate, that there is in their form and position a peculiar provision for the oscillation of sound producing the full effect.

We find, however, that the cochlea is imperfect in birds;

* Scarpa, p. 61.

and that it is fully formed only in man, and in quadrupeds: we must, therefore, conclude, that it is subservient to the more exquisite sensations. I do not conceive that the cochlea or any part of the organ particularly conduces to the bestowing of a musical ear, although it is by hearing that we are capable of the perceptions of melody and harmony, and of all the charms of music; yet it would seem, that this depends upon the mind, and is not an operation confined to the organ. It is enjoyed in a very different degree by those whose simple faculty of hearing is equally perfect.*

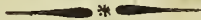
Even after studying, with all diligence, the anatomical structure of the ear, we cannot but be astonished with the varieties to be found in the sensation; for example:—"The ear is capable of perceiving four or five hundred variations of tone in sound, and probably as many different degrees of strength; by combining these, we have above twenty thousand simple sounds that differ either in tone or strength, supposing every tone to be perfect. But it is to be observed, that to make a perfect tone, a great many undulations of elastic air are required, which must all be of equal duration and extent, and follow one another with perfect regularity; and each undulation must be made up of the advance and recoil of innumerable particles of elastic air, whose motions are all uniform in direction, force, and time. Hence we may easily conceive a prodigious variety in the same tone, arising from irregularities of it occasioned by constitution, figure, situation, or manner of striking the sonorous body; from the constitution of the elastic medium, or its being disturbed by other motions; and from the constitution of the ear itself upon which the impression is made. A flute, a violin, a hautbois, a French horn, may all sound the same tone, and be easily distinguishable. Nay, if twenty human voices sound the same note, and with equal strength, there will still be some difference. The same voice, while it retains its proper distinctions, may yet be varied many ways: by sickness or health, youth or age, leanness or fatness, good or bad humour. The same words, spoken by foreigners and natives, nay by different provinces of the same nation, may be distinguished."†

That this variety of sensation does not entirely depend upon the structure, but is the operation of the sense and intellect conjointly, appears from the long experience which is requisite to give this perfection. Nature is bountiful in providing the means of simple and acquired perception, but the latter is the

* See Reid's Enquiry.

† Reid's Enquiry, p. 98.

result of long experience, and continued effort, though we have lost the feeling of its being originally a voluntary effort.



CHAP. VI.

OF THE DISEASES OF THE INTERNAL EAR.

OF all the causes of deafness, that which proceeds from an organic disease of the brain is, of course, the most dangerous. In apoplectic affections, with faltering of speech and blindness, deafness is also produced by the general affection of the brain. • But worst of all is the case where a tumor of the brain, or betwixt the cerebrum and cerebellum, compresses the origin of the nerves.* I have, however, observed, that a tumor in the *vicinity* of the origin of the auditory nerve, though it ran its course so as to prove fatal, had rather a contrary effect on the organ of hearing; and while the pupil of the eye remained stationary, and the man saw indistinctly, he had a morbid acuteness of hearing. This had probably been produced by the surrounding inflammation having extended to the origins of the auditory nerves. The auditory nerve often becomes morbidly sensible, and the patient suffers by the acuteness of perception, or is distressed with the tinnitus aurium, which is, in this case, analogous to the flashes of light which sometimes affect the eye in total darkness, and which those experience who are totally blind or have cataract. So morbidly acute does the sensation sometimes become, that the slightest motion of the head will excite a sensation like the ringing of a great bell close to the ear.† With delirium, vertigo, epilepsy,

* Vidit Clariss. Dom. Drelincurtius Tumorem steatomatis consistentia pugnique magnitudine, cerebrum et cerebellum inter, eo præcisè loco ubi conarium utrique subisteritur choroidis plexus aë, spatio semestri a sensibili læsione, cæcitatem primo, surditatem subinde, omnium denique sensuum et functionum animalium abolitionem et necem ipsam intulisse." Bonet. vol. i. p. 123. ob. 53. In Sandifort Obs. Anatom. Path. tom. i. p. 116. there is an instance in which the auditory nerve had a cartilaginous tumor adhering to it.

† F. Hoffinan. Consult. et Responf. Cas. xxxix.. We must not, however, take his reasoning after what we have seen of the structure of the ear, that the viscid petuita, separated in the concha, cochlea, and labyrinth, resolved into halitus endeavouring to escape, produces the susurrus et tinnitus aurium.

hysteria, the increased sensibility of the organ becomes a source of painful sensation.

In apoplectic affections, with faltering of speech and blindness, there is also deafness; because the affection of the brain is general. With a paralytic state of the muscles of the face, there is deafness of the corresponding ear, if the affection of the nerve be near the brain; which is explained by the strict connection betwixt the auditory nerve and the *nervus communicans faciei*. From observing the course of the *nervus communicans faciei* through the temporal bone, and its connections in the tympanum, we understand why, in violent tooth-ach and in the *tic douloureux* we find the eustachean tube and root of the tongue affected. The ear is sometimes affected by sympathy of parts: for example—from foulness of the stomach and bowels; and the same reason may be assigned for the complaint of hypochondriacs, that they are molested with strange sounds. And in the case of intestinal worms, we find the patient complaining of murmuring and ringing in the ears.* Of the organic diseases of the labyrinth, there is little on record. It would appear, that the fluids become often so altered in their consistence as to prove an absolute destruction to the organ. Mr. Cline found in a person deaf from birth, that the whole labyrinth was filled with a substance like cheese.

A disease of the auditory nerve, like that of the retina in the *gutta serena*, is no unfrequent complaint.†

We ought, at all events, before proposing any operation on the ear, to observe whether the disease be not in the seat of the sense, and such as will not yield to any practice; otherwise, as in the more important operations when done in circumstances which preclude the possibility of success, the public is impressed with its inefficacy and danger, and we are precluded from giving relief on occasions more favourable for our operations.

Deafness, in acute fever, is a good sign; because, say authors, it argues a metastasis of the morbid matter. We should rather say, because it argues a diminution of the morbid sensibility of the brain.‡ But the surcharge of the vessels

* Hoffmann. *Med. Consult.* Boerhaave. The sympathy is sometimes exerted in another way:—"Ex mufices tonitru aut sola meatus auditorii externi contractatione, vomitus urinæ incontinentia." Sauv.

† *Dyscoeca (atonica) sine organorum fonos transmittentium vitio evidente.* Cullen. *Cophosis Sawo.* *Cophosis* a *Paracusi* distinguitur ut *amaurosis* ab *omblyopia* respectiva. Sauv.

‡ But the difficulty of knowing when the deafness is the result of disease, or malconformation in the parts transmitting the sound to the nerve, and when in the brain and nerve, has led to more uncertainty and confusion with regard to the species and varieties of the disorders of the ear than in the eye; where the transparency of the humours assist in the definition.

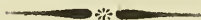
of the brain or of the auditory nerve will also produce deafness and unusual sensations in the ear: as in suppression of the menses and hæmorrhoids, in surfeit, &c. in which cases it is often preceded by vertigo and head-ach.

There occurs a very curious instance of analogy betwixt the ears and eyes in the following cases:—"A certain eminent musician, when he blew the German flute, perceived at the same time the proper sound of it and another sound of the same rhythm or measure, but of a different tone. His hearing seemed thus to be doubled. It was not an echo; for he heard both sounds at one and the same moment: neither were the sounds accordant and harmonious, for that would have been sweet and pleasant to his ear. Having for several days persisted in his attempts, and always been shocked with this grating sound, he at last threw his flute aside. The day before he first became sensible of this strange affection, he had imprudently walked in a very cold and damp evening, and was seized with a catarrh in the right side. Whence, probably, it arose that the natural tone of that ear was altered: the sound appeared more grave, and dissonant from that received by the left ear. Having recovered from the catarrh, the distinct hearing of his ear was restored."

Sauvage, who relates this case, subjoins another:—"Very lately," says he, "a foreigner came for advice in a similar situation. He complained that when any person spoke to him, he heard the proper sound of the voice, and at the same time another sound accompanying it an octave higher, and almost intolerable to him. As it must have happened that if the accompanying sound had preserved the true octave above the voice, and been synchronous with it, the ear would have received them as one sound, and been pleased with their concord: it is probable that the accompanying sound was not in unison with the true." Sauvage, vol. iii. p. 352.

BOOK III.

OF THE NOSE AND THE ORGAN OF SMELLING.



OF THE SENSE OF SMELLING.

SMELLING seems to be the least perfect of the senses. It conveys to us the simplest idea, and is the least subservient to the others. The sensations it presents to us we can less easily recal to memory; and the associations connected with it are less precise and definite than those of the senses of hearing and seeing.

Animal and vegetable bodies, during their life, growth, putrefaction, and fermentation, and, most probably, all bodies whatever, are perpetually giving out effluvia of great subtlety. Those volatile particles, repelling each other, or being diffused in the atmosphere, are inhaled by the nose, and convey to the pituitary membrane of the nose the sensation of smell.

Immediately within the nostrils, there are two cavities separated by the bony partition, which has been already described in treating of the bones. These cavities enlarge as they proceed inward, and open backward into the throat, and, consequently, communicate with the mouth. They extend upwards and sideways into the cells of the bones of the face; and the pituitary membrane is much extended over the surfaces of these winding passages, and over the irregular surfaces of the nose, formed by the projecting cartilages of the æthmoid and lower spongy bones; which, also, have already been sufficiently described.

The cavities of the nose lead into many cells in the bones of the face, which, if not subservient to the organ, assist in giving vibration and tone to the voice. The cavities of the nose are continued upwards into the frontal sinuses, and into the cells of the ethmoid bone; backward and upward into the sphenoid sinus; and upon the sides into the antra highmoriana or sinuses of the upper maxillary bones.

The membrane covering the surface of these bones is called the MEMBRANA SCHNEIDERIANA, the mucous or pituitary membrane. It is of a glandular structure, or is lubricated by the mucus discharged by the follicles on its surface.— This secretion on the surface of the membrane, is to defend its delicate and sensible structure from the effects of the air, while it preserves the sensibility of the surface and the delicate expanded nerve. It seems of a nature to allow the effluvia to penetrate it.

It appears to me, that a very particular provision has been made against the too powerful effect of smells while the membrane is inflamed, and, consequently, in a state of great sensibility. When the membrane is inflamed, the secretion is so altered, that the effluvia do not penetrate so as to effect the nerve in its state of extreme sensibility.

We have already described the course of the first pair of nerves or the olfactory nerves, and also those branches of the common nerves which are distributed to the membrane of the nose. These, it were superfluous to recapitulate here. It was suggested as the most probable opinion, that the olfactory nerve alone is subservient to these parts considered as the organ of smelling, and that the adventitious branches supply merely the common sensibility which the nerves bestow promiscuously over the body. This sensible and nervous membrane, and this glandular and secreting membrane, is extremely vascular, as it is natural a priori to suppose; and this vascularity, this glandular structure, and its exposed state, makes it liable to frequent disease: and, when diseased, when tumours and polypi form in it, we must never forget the extreme thinness and delicacy of the surrounding bones, which, when they are either pressed upon by tumours, or have their membranes eroded, are soon totally destroyed.— It is with manifest design, that the organ which so particularly admonishes us of the effluvia diffused in the air we breathe, should have been placed in the entrance to the canal of the lungs. It is, in some measure, a guard to the lungs, as the sensibility of the tongue guards the alimentary canal. That the humidity of the membrane either preserves the sensibility of the nose, or is a solvent, in which the effluvia dissolving

affect the nerves, is evident ; for the sense is lost when the membrane becomes dried. The sensibility is also affected in various ways by too abundant a mucous discharge, or by an alteration of its natural properties ; by the infarction and thickening of the membrane, as in ozæna ; by obstructions preventing the current of air through the nose, as in polypi, &c.

BOOK IV.

OF THE MOUTH, SALIVARY GLANDS, AND ORGAN OF TASTE.



CHAP. I.

OF THE MOUTH AND TONGUE.

ALTHOUGH it is not necessary to say, that the mouth is “betwixt the nose and chin,” that “there are lips serviceable to the purposes of speaking, eating, and drinking ;” though it be not necessary to lay it down circumstantially, that there are cheeks on the face, and a tongue in the mouth ; yet is there much important anatomy, and very useful knowledge necessary to be acquired here.

Of the **TONGUE**, it is only necessary to observe its form, and the terms used in its description. The **BODY** of the tongue consists of the muscular fibres, with intermingled fat and cellular membrane ; and the muscles which chiefly compose it, are the *linguales*, *styloglossi*, and *genioglossi* muscles.

The **BASE** of the tongue is connected with the *os hyoides*.

The surface applied to the roof of the mouth is the **DORSUM** ; and on this surface there is to be observed a middle line, dividing the tongue into two lateral portions ; a division which is very accurately preserved in the distribution of the blood-vessels and nerves of either side. On the *dorsum*, towards the base, the surface is rough with the *papillæ maximæ* and *foramen cæcum* of *Morgagni*. These *papillæ* are like small glands seated in little superficial *fossulæ*, so that their broad mushroom-like heads alone are seen ; but they are connected with the bottom of the *fossulæ* by short stems or necks. This is al-

together a glandular apparatus. The foramen cæcum is, in truth, only an enlarged apparatus of the same kind, for, in the bottom of this foramen, many glandular papillæ stand up; and in its bottom small foramina have been observed, which are generally conceived to be the mouths of small salivary ducts.* This secreting mucous surface begins here, towards the root of the tongue, to resemble the glandular structure of the œsophagus, which, by bedewing the surface of the morsel, fits it for an easy passage through the gullet. In this roughness of the root of the tongue, there seems to be a provision for the detention of the sapid particles, and the prolonging of the sensations of taste.

The PAPILLÆ peculiar to the human tongue, are divided into four classes. 1. These larger papillæ upon the root of the tongue are the truncatæ; and they are often studded on the dorsum of the tongue in a triangular form. 2. The fungiformes are obtuse papillæ found more forward on the tongue; they are little hemispherical tumid papillæ, or of a cylindrical shape, with an obtuse apex. These are interspersed among the 3d division, the most numerous and universally prevalent papillæ, viz. villosi or conicæ. 4. The more important papillæ, however, are those which are endowed with peculiar sensibility to sapid bodies; they are to be distinguished by their superior redness and brilliancy upon the point and edges of the tongue.

The tongue is invested with the cuticle and rete mucosum like the skin in other parts. The lower surface of the tongue is similar to the general lining membrane of the mouth, being a villous and secreting surface. It is reflected off upon the bottom of the mouth. It forms here the frenulum linguæ. This ligament seems evidently intended to limit the motion of the point of the tongue backwards. I believe a very false opinion has much prevailed, that the shortness of this ligament, or its being continued too far forward toward the point of the tongue, prevents the child from sucking. The tongue, as I conceive, would sufficiently perform the necessary action on the mother's nipple, although its lower surface were universally adhering to the bottom of the mouth. But, observe the bad consequences which may arise from cutting this frenulum, from the obstinate importunity of the nurse, or the weakness of a surgeon. The ranine vein or artery which runs near it may be cut, and the child will continue sucking and swallowing its own blood; and children have actually died, and the stomach has been found

* Vater, who injected these ducts, found them terminating in a gland near the os hyoides; and his opinion was, that they had even a connection with the thyroid gland. Heister was of the same opinion.

distended with blood ! But there is another more dreadful accident from this cutting of the frenum linguæ. A child, says Mr. Petit, whose frenum had been cut almost immediately after its birth, was suffocated, and died five hours afterwards. They believed that the operation was the cause of the child's death ; they sent for me to open the body. I put my finger into its mouth, and I did not find the point of the tongue, but only a mass of flesh; which stopped up the passage from the mouth into the throat. I cut up the cheeks to the masseter muscles, to see what had become of the tongue ; I found it turned like a valve upon the fauces, and the point actually swallowed into the pharynx. "Some time after," continues Mr. Petit, "I was called to the child of Mr. Varin, Sellier du Roi, whose frenum they had cut two hours after its birth, and who, a little after; had fallen into the same situation with the child I have now mentioned, and was nearly suffocated. My first care was, to introduce my finger, the tongue was not, as yet, entirely reversed into the throat. I brought it back into the mouth ; in doing which, it made a noise like a piston when drawn out of its syringe." Mr. Petit waited to find the effect of its sucking, and, after hearing the action of deglutition for some minutes, the child fell again into the same state of suffocation. Several times he reduced the tongue, and, at last, contrived a bandage to preserve it in its place ; but, by the carelessness of the nurse, the accident recurred, and the child was suffocated during the night.



CHAP. II.

OF THE SALIVARY GLANDS.

THE sources of the saliva are very numerous ; the parotid glands or superior maxillary gland, and socia parotidis ; the inferior maxillary or submaxillary glands ; the sublingual glands ; and, (according to the opinion of many,) the glandular follicles of the root of the tongue : the palate, and even

the buccinales and labiales, or glands of the cheeks and lips, are also to be enumerated, as sources of saliva.

The **PAROTID GLAND**, as its name implies, is that which lies near to the ear. It is the largest of the salivary glands; and it is of much importance for the surgeon to observe its extent and connections. A great part of it lies before the ear, and betwixt the ear and jaw. It extends over the masseter muscle, and upward to the zygoma. But there is also great part of it which lies below the tip of the ear, and betwixt the angle of the jaw and the mastoid process. Its surface is unequal, and composed of little masses or lobules of gland, united by a cellular membrane. The duct of this gland was discovered by Needham, and afterwards by Steno: it is very often called Steno's duct. When it is injected with quick-silver, the branches are seen distributed in a most beautiful and minute manner amongst the lobuli of the gland, and similar to the branching of veins. These branches have a direction upward, and unite into a trunk, which passes from the upper part of the gland across the cheek over the origin of the masseter muscle: it then pierces the buccinator muscle, and opens upon the inner surface of the cheek, opposite to the second or third dens molaris. This duct has strong white coats; but, although the mouth of the duct is very small, the duct itself is dilatable to a great size, so that tubes of a considerable size have slipped into it, and been buried in the body of the gland.

The **SOCIA PAROTIDIS** is a small gland, (which, however, is by no means constant,) seated on the upper side of the duct of the parotid gland, and just under the margin of the cheek-bone. It opens by a lesser duct into the great duct of Steno.— Sometimes, however, instead of one considerable gland, there are several small ones, seated in the course of the great duct, and opening into it by several minute ducts.

OF THE SUBMAXILLARY AND SUBLINGUAL GLANDS. The submaxillary gland is of a regular oval figure; it lies on the tendon of the digastric muscle, and is defended by the angle of the lower jaw, while it is generally connected with, or involves the root of the facial artery. It is regularly lobulated: and its duct passes forward between the genioglossus and mylo-hyoideus, and under the sublingual gland. The openings of the submaxillary ducts, or ducts of Wharton, are very easily distinguished. They open very near each other on each side of the frenum linguæ, very near the gums of the dentes incisivi; so that they appear as if tied down by the frenum.— When these are excited to discharge their fluids, they become a little erected, their patent mouths are seen distinctly, and the

tortuous course of their canal in the bottom of their mouth may be observed.

The **SUBLINGUAL GLAND** is of a flat and elongated form ; it lies close under the tongue between the geniohyo-glossus and mylo-hyoideus muscles. It is the smallest of the three great salivary glands. The two sublingual glands stretching closely under the tongue, they are separated from the mouth only by the membrane of the mouth. They have no large duct, but open by small lateral ducts, with loose pendulous mouths upon the lower surface of the tongue. Besides the lesser glands, which every where are found under the lining membrane of the mouth, Heister, Verdier, and M. de Bordeu, have described a glandula molaris, seated betwixt the buccinator and masseter muscles.

From the general surface of the lips, tongue, cheek, and palate, there is a fluid exhaled. This exhaling surface, and all those glands, are excited to action by the same stimulus with the membrane of the mouth. The saliva moistens the surface of the mouth, assists in manducation, and preparing the food to be swallowed and acted upon by the stomach, and accelerates digestion. As the mouth is an exhaling surface, so is it an imbibing and absorbing surface.



CHAP. III.

VELUM PALATINUM ; UVULA ; ARCHES OF THE PALATE ; AND AMYGDALÆ.

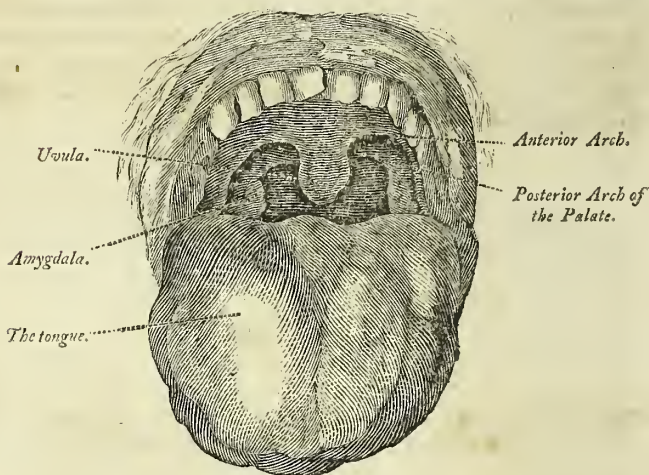
THE **VELUM PENDULUM PALATI** is the vascular and fleshy membrane, which, hanging from the bones of the palate, divides the mouth from the fauces and throat. It is not a simple membrane, but has betwixt its laminæ many glands, which open upon its surface by little patent follicules, and is thickened and strengthened by muscular fibres : so that it is more of a fleshy partition, stretching backward and eking out the palate, than a hanging membrane.

The edge of the velum palati is not square, but turned into elegant arches ; and, from the middle of the arches of the pal-

ate, hangs down the *UVULA*, so named from its resemblance to a grape. It is a large, soft, and glandular papilla, peculiarly irritable and moveable, having in it muscular fibres, and hanging from the moveable soft palate. It seems to hang as a guard over the fauces, and, by its sensibility, in a great degree governs the operation of these parts.

The *ARCHES OF THE PALATE OR FAUCES* descend on each side from the *VELUM PALATI*. They are muscular fibres, covered with the soft vascular and follicular membrane of the fauces.* There are two on each side. These arches stand at some distance from each other, so that the isthmus of the fauces resembles the double-arched gateway of a citadel, or the arched roof of a cathedral, with the uvula hanging as from the central union of four semicircular arches.

Fig. 20.



Behind the soft palate is the opening of the nose backward into the throat. Now, the use of the velum is that in swallowing it may be drawn up like a valve upon the posterior opening of the nose; and there being, at the same time, an action of the arches of the palate, the whole is brought into a funnel-like shape, directing the morsel into the pharynx and gullet. In this action, the direction of the food assists, but,

* See vol. I. *Constrictor Isthmi faucium and Palato-pharyngeus.*

in vomiting, the valvular-like action of the velum is not so accurate; and often the nose is assailed with the contents of the stomach.

AMYGDALÆ. Under the velum palati, and betwixt the arches of the palate on each side, lies a large oval gland of the size and shape of an almond. These are the tonsils or amygdalæ. The amygdala is a mucous gland: it is loosely covered with the investing membrane of these parts: its surface is seen, even in a living person, to be full of large cells like lacunæ; these communicate; and the lesser mouths of the ducts open into them. The gland is of a soft relaxed nature, adapting itself to the extensive motion of those parts. From this naturally loose texture, and from its being a vascular and secreting body, exposed to the immediate vicissitudes of weather, it is often inflamed, and greatly impedes the action of the surrounding muscular fibres in the action of deglutition. The use of the amygdala is evidently to lubricate the passage of the throat, and facilitate the swallowing of the morsel; and, for this reason, are the mouths of its ducts cellular and irregular, that they may retain the mucus until ejected by the action of deglutition. In this operation, the amygdalæ are assisted by numerous lesser glands, which extend all over the arches of the palate and pharynx. But these are parts which come again to be recapitulated, as introductory to the account of the structure of the œsophagus and stomach, in the succeeding volume.

CHAP. IV.

OF THE SENSE OF TASTING.

ON the surface of the tongue are to be observed erect papillæ. In these the extremities of the gustatory nerve are expended, and they are the seat of the sense of tasting. These papillæ are in the true skin of the tongue, and are extremely vascular. They are covered by the rete mucosum, and a very fine cuticle, and indeed they have much resemblance to the papillæ of the skin; while, betwixt these papillæ, there is a fleece

or down bearing a perfect analogy to the villi of the skin. The papillæ, which are the organs of taste, are to be seen on the point and edge of the tongue, and consist of a pretty large vascular soft point which projects from an opaque and white sheath. If we take a pencil and a little vinegar, and touch or even rub it strongly on the surface of the tongue, where those papillæ are not, the sensation only of a cold liquid is felt; but when you touch one of these papillæ with the point of the brush, and at the same time apply a magnifying glass, it is seen to stand erect and rise conspicuously from its sheath, and the acid taste is felt to pass as it were backward to the root of the tongue. The exquisitely sensible papillæ are placed only on the point and edge of the tongue; for the middle of the tongue is rough, and scabrous, not to give the sensation of taste, but to force the sapid juices from the morsel, or break down the solids against the roof of the mouth, and assist in their solution. The more delicate and vascular papillæ would be exposed to injury if situated on the middle of the tongue. Before we taste, the substance dissolved in the saliva flows over the edges and point of the tongue, and then only comes in contact with the organ of taste.

It would appear, that every thing which affects the taste must be soluble in the saliva; for without being dissolved in this fluid, it cannot enter readily into the pores and inequalities of the tongue's surface.

A curious circumstance, in the sense of taste, is its subserviency to the act of swallowing. When a morsel is in the mouth and the taste is perfect, our enjoyment is not full: there follows such a state of excitement in the uvula and fauces, that we are irresistibly led to allow the morsel to fall backward, when the tongue and muscles of the fauces seize upon it with a voracious and convulsive grasp and convey it into the stomach.—The measure of enjoyment is then full. This last short-lived gout is the acmé. Were not this appetite of the throat and uvula connected with the action which impels the food into the stomach, the complete enjoyment of the sense of taste alone would preclude the brutal resource of the Roman feasts: but as it is, the connection of the stomach and tongue is such, that the fulness of the stomach precludes the further enjoyment of the sense of taste. The senses of smelling and taste have their natural appetites or relish; but they have also their acquired appetites, or delight in things which to unsophisticated nature are disagreeable: so that we acquire a liking to snuff, tobacco, spirits, and opium. "Nature, indeed, seems studiously to have set bounds to the pleasures and pains we have by these two senses, and to have con-

fined them within very narrow limits, that we might not place any part of our happiness in them; there being hardly any smell or taste so disagreeable that use will not make it tolerable, and at last, perhaps, agreeable; nor any so agreeable as not to lose its relish by constant use. Neither is there any pleasure or pain of these senses which is not introduced or followed by some degree of its contrary which nearly balances it. So that we may here apply the beautiful allegory of the divine Socrates: "That although pleasure and pain are contrary in their nature, and their faces look different ways, yet Jupiter hath tied them so together, that he who lays hold of the one draws the other along with it."

BOOK V.

OF THE SKIN AND OF THE SENSE OF TOUCH.



OF TOUCH AND OF THE SKIN.

BY the sense of touch we perceive several qualities, and of very different kinds: hardness, softness, figure, solidity, motion, extension, and heat and cold. Now, although heat be a quality, and cold the privation of that quality, yet in relation to the body, heat and cold are distinct sensations. But in a more precise acceptation of the term, the sense of touch is said to be the change arising in the mind from external bodies applied to the skin, and more especially to the ends of the fingers.

To understand the organization adapted to this sense, we must premise, in a short view, the structure of the skin.

OF THE SKIN.

The skin is divisible, by the art of the anatomist, into four laminæ or membranes, distinct in texture and appearance as in their function or use, viz. the cuticle, or epidermis; the corpus mucosum, or reticular tissue; the cutis vera dermis, or true skin: but from this last there is separated a vascular membrane, below which is the organized surface of the true skin.

The **CUTICLE** OR **EPIDERMIS**, OR **SCARF SKIN**, is the most superficial lamina of the skin: it is a transparent and insensible pellicle which serves, in some degree, to resist the impression of external bodies on the surface of the body, and to blunt the otherways too acute sensation of the cutis vera. In

man it is very thin, unless in those parts which are exposed to the contact of hard bodies, as the palms of the hands and soles of the feet. The thickness of the cuticle there, however, is not altogether the effect of labour and walking, but there is even in the *tætus* a provision for the defence of the skin in these places. This is particular, that by labour or continued pressure on the cuticle it does not abrade and become thin and tender, but thicker, harder, and the part more insensible, so as even to acquire a horny hardness and transparency. Of this we have an example in the hands of smiths, and in a remarkable manner in the feet of those who have been accustomed to walk bare-foot on the burning sands. It is thus a protection in a state of nature; but when the foot comes to be unnaturally pinched in shoes, the hard leather works perpetually on a point of the toes, excites the formation of cuticle in the skin below, which thrown outward by succeeding layers of cuticle, at last forms a corn or *clavus*, and which, like a small nail, has a broad head with a conical point shooting into the tender skin.

The cuticle is perforated by the extremities of the perspiring and absorbing vessels, and by the ducts of the glands of the skin. Indeed, when the small pores of the skin or *foramina* are examined narrowly, the cuticle is seen to form sheaths which enter into them, and which, when torn out, are like little tubes having a perforated point.

When, by maceration, the cuticle is separated from the skin, as we draw it off we see little processes of the cuticle, which enter into the pores of the skin.

Mr. Cruickshanks enumerates three classes of processes: there appear evidently two. The first lines the pores through which the hairs pass: these are the longest, and generally have the longest diameter. The second class is easily distinguished on the inside of the cuticle, which covers the palms of the hands or soles of the feet, or indeed on any part of the cuticle; and they appear in regular order on those parts of the cuticle which correspond with the parallel or spiral ridges of the *cutis*. The surface of the cuticle is uniform next the skin; but, on the outer surface, it is rough and squamous. These *squamæ* are the portions of the cuticle, which, breaking up, are rubbed off; and thus there is a perpetual change, by the formation of new cuticle under the old, and the abrasion or desquamation of the old surface.

In youth, the cuticle is thin and transparent; in old age, it becomes thick, rough, and furrowed:

————deformem pro cute pellem
Pendenteisque genas et taleis adspice rugas

Qualeis umbriferos ubi pandit tabraca factus
In vetula scalpit jam mater fimia bucca.

The NAILS are naturally connected with the cuticle, for they remain attached to it, and separate from the true skin by maceration and beginning putrefaction. The nails are to give firmness and resistance to the points of the fingers. Although they take a very universal adhesion, it is chiefly from the root that they grow and shoot out to the point of the fingers, to which they adhere firmly. Over the root of the nail the cuticle projects, and under it the rete mucosum is extended; and under this, and defended by it, are the papillæ of the skin also.

Like the cuticle, the nails are without vessels or sensation: they are undergoing a perpetual growth, and are worn down by labour. When cherished, they grow to an amazing length, and curve a little over the points of the fingers; and serve, in some nations, as a most unequivocal sign of perfect idleness and consequent gentility, since the fingers become absolutely useless. By disease, I have seen very large crooked horns projecting from the stool of the nail of the toes. They were thus monstrously increased by superimposed laminæ shoved off by the more recent ones.

OF THE HAIRS.

The hairs grow from a bulbous root, seated in the cellular membrane. This bulb is vascular, and has connection, by vessels, with the cellular texture. It consists of a double membrane; the outer is a kind of capsule which surrounds the other, and stops at the pore in the skin, and does not form part of the hair. Betwixt these capsules, there is a cellular tissue, and the space is commonly found filled with a bloody fluid. In the bottom of the inner sac, there is a small body, called *monticule* by Duverney, from which the hair is seen to arise; and if this is left when the bulb of the hair is pulled out, the hair will be regenerated.

The root of the hairs, says Mr. Winslow, is covered by a strong white membrane, which is connected with the skin and cellular membrane. Within the root, there is a kind of glue, some fine filaments of which advance to form the stem which passes through the small extremity of the bulb to the skin.—As the stem passes through the root, the outer membrane is elongated in form of a tube, which closely invests the stem and is entirely united with it. And many authors agree, that the hair does not perforate the cuticle, but takes from it merely a *vagina* which accompanies it.

RETE MUCOSUM.

The rete or corpus mucosum, lies betwixt the cuticle and the surface of the true skin. It is a mucous layer, pervaded by the little fibrillæ passing betwixt the skin and cuticle. I consider it as a soft bed to envelope and preserve the papillæ of the skin, and as intended to become cuticle in due succession. It was considered, by Albinus, as of a nature adapted to imbibe the fluids through the cuticle, and as a production of the epidermis. M. Meckel believed it to be only a mucous fluid, inspissated into the form of a membrane; and that it was dissolved by putrefaction, while the skin and cuticle remained firm. It is the seat of colour in the skin, and is of a white transparency in the albino, and in the inhabitants of temperate climates. It is black in the negro; copper-coloured in the mulatto; yellow in the Egyptian. It is supposed to preserve the negro from the heat of the climate; but I conceive that the power of resisting the baneful effects of warm climates, must be looked for in other constitutional peculiarities: for certainly a surface which absorbs the light must produce heat more rapidly than a white one, which repels it. The ladies know that the effect of a black veil, in intense sun-shine, is to scorch the cheeks. The rete mucosum changes its shades of colour in Europeans, from the effect of light, and sometimes makes changes in the constitution, as in the colour of the areolæ which surround the nipple.

While the rete mucosum has its peculiar use of defending the delicate surface of the papillæ of the skin, I conceive it to be undergoing a perpetual change; to be thrown off in succession from the vascular surface of the skin, and in its turn to form the cuticle by its outer layers. The inner surface of the rete mucosum is softer and more pulpy, the outward surface more allied to the cuticle, which gives occasion to Mr. Cruickshanks to say it is double.

Under the rete mucosum and on the surface of the skin, there is a soft vascular membrane, which is still above the porous and glandular true skin. It was first demonstrated by injections in subjects who had died of small-pox, and is also so much strengthened by other inflammatory actions of the vessels of the skin, as to be capable of demonstration. It was at first supposed that this vascular membrane was the rete mucosum successfully injected; but afterwards it was found, that this vascular membrane existed independently of the rete mu-

cosum.* Mr. Cruickshanks conceives that it is cuticle in its state of formation, and that the rete mucosum is in fact a cuticle advancing to the state of perfect maturation. But I should rather believe that this is a vascular surface, not changeable, nor losing its vascularity to be thrown off in form of rete mucosum; but, in itself, the organized surface, which is to form the rete mucosum, and which excretion does in succession become cuticle. This vascular surface of the skin, for such I must suppose it, although it be capable of being separated by long maceration and putrefaction, into something like a distinct membrane, is the seat of the small-pox pustule, and probably of many other cutaneous diseases.

There are three laminæ above the true skin, distinguished by their character; the cuticle, the rete mucosum, and the vascular membrane: but as some have divided the rete mucosum into the lamina, Mr. Cruickshanks has separated two vascular layers from the surface of the skin. They, who are fond of such minute subdivisions, may thus enumerate five laminæ or membranes, before coming to the porous surface of the true skin.

OF THE TRUE SKIN.

The true skin is the dense, elastic, and vascular membrane which is under these outer laminæ, already treated of. While it has firmness, strength, and elasticity to defend the body; it is also an organized surface, as important in its function and the healthy action of the system depending upon it nearly as closely as on the action of the lungs and surface of the intestines.

The skin is dense on the outer surface, while the internal layers are loose, and gradually degenerate into the cellular substance. On the lips, eye-lids, &c. the skin becomes thin and transparent.

We have to attend to the pores and villi of the skin; on narrowly observing the surface of the skin, we find it irregularly porous. These are the ducts of sebaceous glands, which are lodged in the skin. They transmit the hairs also, and are the perspiring and, probably, the absorbing pores; or, at least, within these larger pores it is probable the absorbing and transpiring vessels terminate. These pores are most remarkable about the nose, mouth, palms of the hands, and soles of the

* Mr. Baynham, who discovered this vascular surface, conceived that he had injected the rete mucosum. We are to find the further elucidation of this piece of anatomy from Mr. Cruickshanks.

feet. Into these pores of the true skin, as we have mentioned, little sheaths of the cuticle enter, and through these sheaths the perspiring matter must consequently escape. But, in death, the action of the perspiring vessels ceasing, the pores of the cuticle are no longer pervious to the fluids, and there is no perspiration or exudation through them.

The villi of the skin project above its surface, like the pile of velvet. They vary much in size, and are, in some places, very much prolonged. They conduct the sensible extremities of the cutaneous nerves to form the organ of the sense of touching; and, like the papillæ of the tongue, they suffer an erection and excitement preparatory to the reception of the impression.

Fig. 1.



Fig. 2.



EXPLANATION
OF THE
PLATES.



PLATE V.

FIG. 1.

THE eye with the cornea cut away, and the sclerotic coat dissected back.*

- a. THE OPTIC NERVE.
- b. THE SCLEROTIC COAT dissected back, so as to show the vessels and nerves of the choroid coat.
- c. c. THE CILIARY NERVES seen piercing the sclerotic coat, and passing forward to be distributed to the iris.
- d. A small nerve passing from the same source to the same destination, but appearing to give off no branches.
- e. e. TWO of the VENÆ VORTICOSÆ.
- f. A point of the sclerotic coat through which the trunk of one of the veins had passed.
- g. A lesser venous trunk.
- h. The orbiculus ciliaris of Zinn; the ciliary ligaments of others.
- i. The IRIS.
- k. The straight fibres of the iris.
- l. A circle of fibres or vessels which divide the iris into the larger circle k, and the lesser circle m.
- m. This points to the lesser circle of the iris.
- n. The fibres of the lesser circle.
- o. The pupil.

* See Zinn, Tab. iv.

FIG. 2.

A dissection of the coats of the eye, as they appeared when hung in spirits.

- A. The OPTIC NERVE.
- B. The SCLEROTIC COAT folded back.
- C. The CHOROID COAT hanging by its attachment to the sclerotic coat.
- D. The vessels of the RETINA seen as they appeared suspended in the fluid; the medullary part of this coat being washed away.



EXPLANATION OF PLATE VI.

FIG. 1.

The LENS covered with its capsule, and minutely injected in the fœtus calf.

- A. The ARTERIA CENTRALIS RETINÆ.
- B. The fringe remaining with the margin of the lens from the attachment of the vessels of the ciliary body.

FIG. 2.

This figure shews the attachment of the capsule of the lens to the membrana pupillaris, in the fœtus calf.

- A. The capsule of the lens very minutely injected; the lens has been allowed to escape, and the membrane hangs by its attachment to the membrana pupillaris.
- B. That part of the capsule which covers the fore part of the lens; in which, not a vessel is to be seen.
- C. The MEMBRANA PUPILLARIS, very minutely injected.
- D. The IRIS, to the circle of which, the membrana pupillaris is seen to be attached, and, consequently, to close the pupil.
- E. The CILIARY PROCESSES.

FIG. 3.

The CILIARY PROCESSES, the IRIS, and MEMBRANA PUPILLARIS, as they appear in the human fœtus of the seventh month.

Fig. 1.



Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.



Fig. 1.

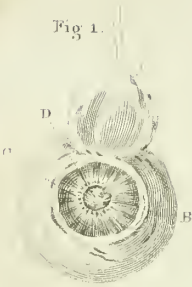


Fig. 2.



Fig. 3.

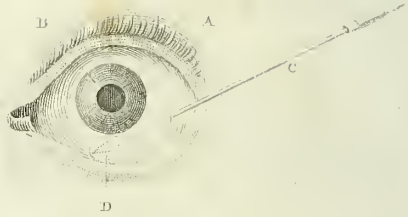


Fig. 4.

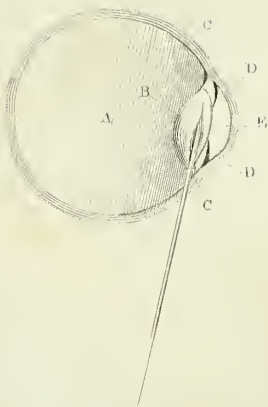


Fig. 5.

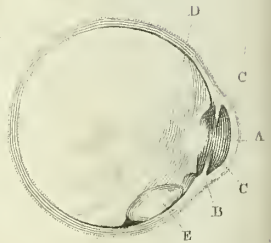


FIG. 4.

The appearance of a vessel which took its course across the pupil in the full-grown fœtus, indicating, that the membrana pupillaris was still present, although it had become pellucid.

FIG. 5.

A section of the optic nerve, to show its great degree of vascularity.

- A. The body of the nerve quite red with injection.
- B. The coat of the nerve.



EXPLANATION OF PLATE VII.

FIG. 1.

The representation of an eye with a cataract, dissected.

- A. The CORNEA cut from the sclerotic coat, and hanging by a shred.
- B. The SCLEROTIC COAT.
- C. The IRIS.
- D. The OPAQUE LENS OR CATARACT, it is seen to have formed an adhesion with the iris.

FIG. 2.

This figure represents the effect of couching a soft cataract. The needle, instead of depressing the cataract, cut it into three pieces.

- A A. The cut edge of the SCLEROTIC COAT.
- B. The CHOROID COAT, and CILIARY PROCESSES.
- C. The cataract adhering to the ciliary processes in three distinct pieces.

FIG. 3.

This figure represents the place into which the couching needle must be introduced.

- A. The PUPIL seen through the transparent cornea.

- B. The IRIS.
- C. The NEEDLE, with the handle elevated, so as to depress the point.
- D. The lens and point of the needle in outline ; this represents the position of the lens when depressed : to complete the operation, it must be carried a little back before withdrawing the needle.

FIG. 4.

A scheme, shewing the bad effect of introducing the needle near the margin of the cornea.

- A. The VITREOUS HUMOUR.
- B. The LENS.
- C C. The CILIARY BODY ; on the lower part, torn by the needle.
- D D. The IRIS.
- E. The anterior chamber of the aqueous humour.

FIG. 5.

Shows the situation of the cataract when depressed.

- A. The ANTERIOR CHAMBER of the aqueous humour.
- B. The POSTERIOR CHAMBER of the aqueous humour.
- C. The iris.
- D. The VITREOUS HUMOUR occupying the seat of the lens.
- E. The depressed lens or cataract.



EXPLANATION OF PLATE VIII.

Showing some varieties in the structure of the ear in the lower animals.

FIG. 1.

The ear of the lobster.

- A. The membrane which covers the projecting mouth of the shell containing the organ of hearing.
- B. A transparent pulp or vesicle, upon the bottom of which, the web of the nerve is expanded.
- C. The inside of the shell containing the organ, which is, of course, represented broken open.

Fig. 1.



Fig. 7.

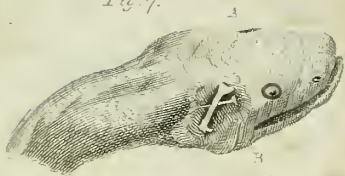


Fig. 2.



Fig. 8.

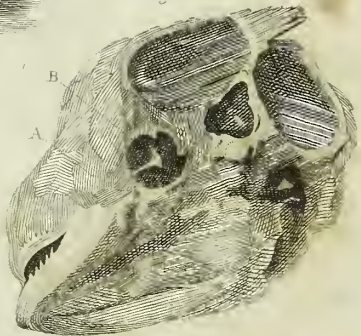


Fig. 3.

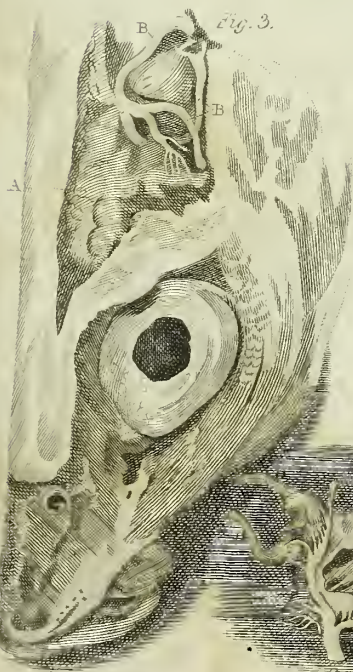


Fig. 5.



Fig. 6.



Fig. 4.

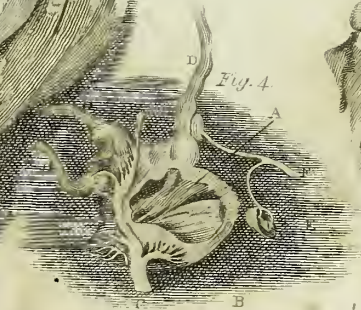




FIG. 2.

This represents a little bone which is suspended in contact with the pulp of the nerve, and which is seen but imperfectly in the first figure.

- A. The bone.
- B. An elastic membranous, or rather, cartilaginous substance, by which the bone is suspended.

FIG. 3.

The head of a haddock with the bones broken up, to shew the brain and semicircular canals.

- A. The BRAIN.
- C. The SEMICIRCULAR CANALS.

FIG. 4.

The organ of hearing taken out and displayed.

- A. The SACCULUS VESTIBULI.
- B. The bony concretion which lies within, and which, by its vibration, increases the impulse.
- C. The AUDITORY NERVE passing to be distributed on the sacculus vestibuli, and the extremities of the semicircular canals.
- D D D. The three SEMICIRCULAR CANALS.
- E. One of the extremities of the semicircular canals in which the branch of the nerve is seen to be expanded.
- F. A lesser division of the auditory nerve.

FIG. 5.

The head of a frog with the skin taken off: and we now see the cavity of the tympanum in this animal, over which the common integuments of the head spread tense, so as to answer the purpose of the membrana tympani.

- A. The point of a little elastic bone which is attached behind the tense integuments, and receives their vibration.— Its further connections are seen in the next figure.

FIG. 6.

A magnified view of the internal structure of the frog's ear.

- A. The first bone, which is attached to the skin.
- B. The second bone, which has its inner extremity enlarged

so as to fill up the foramen ovale, which leads into the inner cavity of the ear.

- c. The great inner cavity of the ear of this animal, answering to the vestibule of the more perfect structure.
- d. A chalky concretion which lies within this cavity.

FIG. 7.

The head of a serpent.

- A. A bone connected with the lower jaw.
- B. A bone which passes from the integuments (behind the large bone A) to the opening into the cavity of the ear, and which, of course, receives and conveys the vibration of sound into the cavity which contains the expanded nerve.

FIG. 8.

The HEAD of the LAND TORTOISE.

- A. A large scale which serves the use of the membrana tympani.
- B. A single bone which is seen to pass through the cavity of the tympanum: it is attached by an elastic brush of fibres to the scale A, and is enlarged to a head upon its inner extremity. This, filling up the foramen of the inner cavity, conveys the vibration.



EXPLANATION OF PLATE IX.

In this plate, the anatomy of the bones of the human ear is explained.

FIG. 1.

We have here the bones which form the chain betwixt the membrane of the tympanum and the membrane of the foramen ovale.

- A. The MALLEUS.
- B. The INCUS.
- C. The STAPES.

Fig. 2.



Fig. 4.

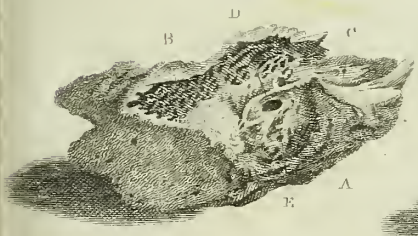


Fig. 3.



Fig. 5.

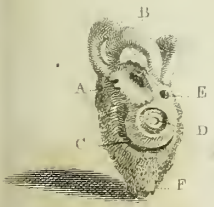
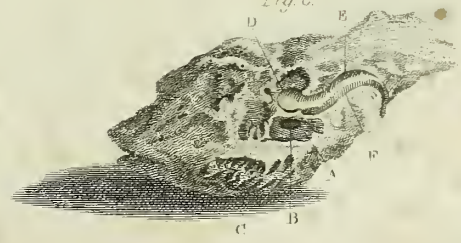


Fig. 6.



- D. The **OS ORBICULARE** which forms the articulation betwixt the incus and stapes.

FIG. 2.

In this figure, we have a view of the inside of the temporal bone, the petrous portion being broken away : we see the cavity of the tympanum, the membrane of the tympanum, and the chain of bones.

- A. The groove for the lodgement of the lateral sinus.
 B. The hole in the sphenoid bone for the passage of the artery of the dura mater.
 C. The petrous portion of the temporal bone.
 D. The irregular **CAVITY** of the **TYMPANUM** laid open by the breaking off of the petrous part of the temporal bone.
 E. The **MEMBRANE** of the **TYMPANUM** closing the bottom of the meatus auditorius externus.
 F. The **MALLEUS**, the long handle of which is seen to be attached to the membrane of the tympanum E.
 G. The **INCUS**, united to the great head of the malleus F.
 H. The **STAPES**, which is seen to be articulated with the long extremity of the incus through the intervention of the os orbiculare.

FIG. 3.

Shows the division of the temporal bone into the squamous and petrous portions.

FIG. 4.

- A. The **SQUAMOUS PART** of the temporal bone.
 B. The **CIRCULAR RING**, which forms the meatus auditorius externus in the child.
 C. The **ZIGOMATIC PROCESS**.
 D. Cells, which afterwards enlarge into those of the mastoid process.

FIG. 5.

The petrous portion of the bone, with a view of the tympanum.

- A. The **CAVITY** of the **TYMPANUM**.
 B. **MASTOID CELLS**.

- D. The FORAMEN OVALE, into which the stapes (see fig. 1. G. and fig. 2. H.) is lodged.
- E. The more irregular opening of the FORAMEN ROTUNDUM.

FIG. 6.

Represents the labyrinth of the human ear, with the solid bone which surrounds it cut away.

- A. The FORAMEN OVALE.
- B. The three SEMICIRCULAR CANALS.
- D. The COCHLEA.
- E. The tube, which conducts the portio dura of the seventh pair through the temporal bone.

FIG. 7.

Explains the manner in which the lamina spiralis divides the cochlea into two scalæ, and the opening of the one scala into the common cavity of the vestibule, and the termination of the other in the foramen rotundum.

- A. The bone broken, so as to show the cavity of the tympanum.
- B. The FORAMEN OVALE.
- C. Cellular structure of the bone.
- D. The FORAMEN ROTUNDUM.
- E. One of the SCALÆ of the cochlea, which is seen to terminate in the foramen rotundum.
- F. The other scala, which is seen to communicate with the vestibule.

EXPLANATION OF PLATE X.

These two figures are taken from the beautiful plates of Professor Scarpa, and illustrate the soft parts contained within the osseous labyrinth, and the distribution of the nerves.

FIG. 1.

There is seen the membranous semicircular canals, their common belly, and the distribution of the acoustic or auditory nerve.

- a. The AMPULLA of the superior membranous semicircular canal.

Fig. 1.

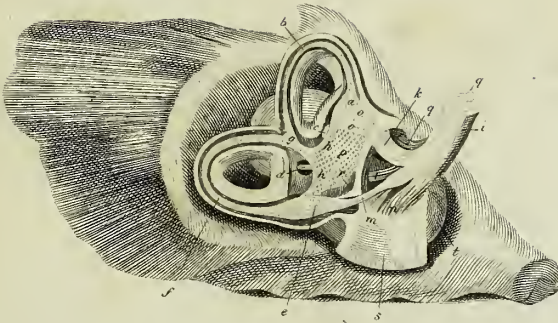
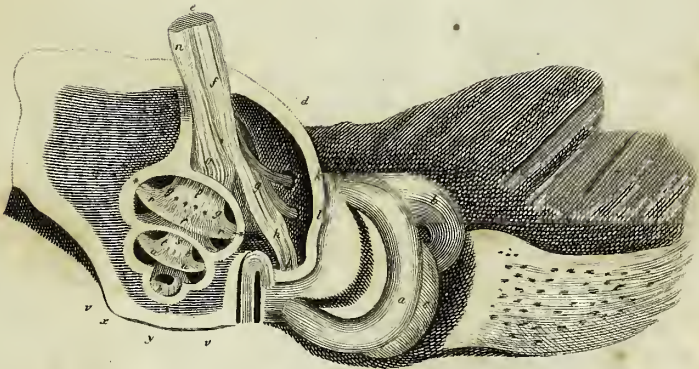


Fig. 2.





- b. The SUPERIOR MEMBRANOUS SEMICIRCULAR CANAL.
- c. The AMPULLA of the external membranous canal.
- d. The other extremity of the external canal.
- e. The AMPULLA of the posterior membranous semicircular canal.
- f. The POSTERIOR SEMICIRCULAR CANAL.
- g. The common canal of the superior and posterior canal.
- h h. The sac common to the membranous semicircular canals, viz. the ALVEUS COMMUNIS.
- i. The body or trunk of the ACUSTIC NERVE.
- k. The larger branch of the nerve.
- l. A filament of the nerve to the sacculus vestibuli.
- m. The lesser branch of the acoustic nerve.
- n. A filament of the cochlea.
- o o. Filaments of the larger branch of the acoustic nerve to the ampullæ of the superior and exterior semicircular canals.
- p. The expansion of the nerve on the common alveus.
- q q. NERVUS COMMUNICANS FACIEI OR PORTIO DURA.
- r. The beginning of the spiral lamina of the cochlea.
- s. The osseous canal of the nerve, which forms part of the foramen auditorius internus.
- t. The COCHLEA.

FIG. 2.

The distribution of the nerve in the cochlea seen by a section of the internal auditory canal and cochlea.

- a. The SUPERIOR OSSEOUS SEMICIRCULAR CANAL.
- b. The posterior osseous semicircular canal.
- c. The external osseous semicircular canal.
- d. The bottom of the great FORAMEN AUDITORIUS INTERNUS.
- e. The trunk of the great acoustic nerve.
- f. The ANTERIOR FASCICULUS of the acoustic nerve.
- g. A plexiform twisting in the anterior fasciculus of the nerve.
- h. A gangliform swelling of the nerve.
- i. The greater branch of the anterior fasciculus.
- k. The lesser branch.
- l. A filament of the anterior fasciculus to the hemispherical vesicle of the vestibule.
- m. A branch to the beginning of the lamina spiralis.
- n. The POSTERIOR FASCICULUS of the acoustic nerve.
- o. The filaments about to enter the tractus spiralis foraminulosus.

- p. These nerves seen upon the modiulus.
q q. The filaments of the nerve passing forward betwixt the two planes of the lamina spiralis.
r r. Their termination on the soft part of the lamina spiralis.
s. The nerves expanded on the second gyrus of the modiulus.
t t u u. Their further distribution on the lamina spiralis.
v v. The INFUNDIBULUM.
x y. The last turn and termination of the lamina spiralis in the infundibulum.

END OF THE THIRD VOLUME.

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Bell, J.
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1812

